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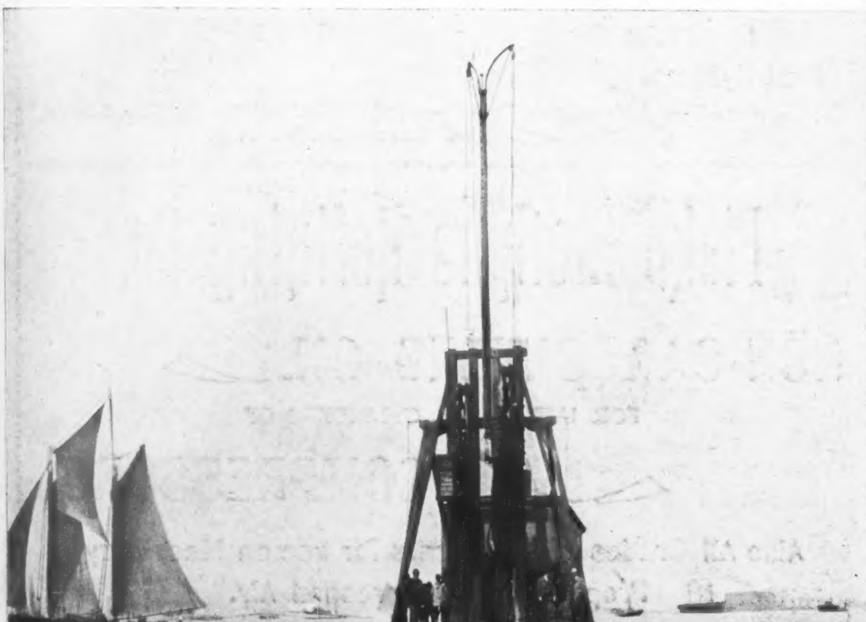

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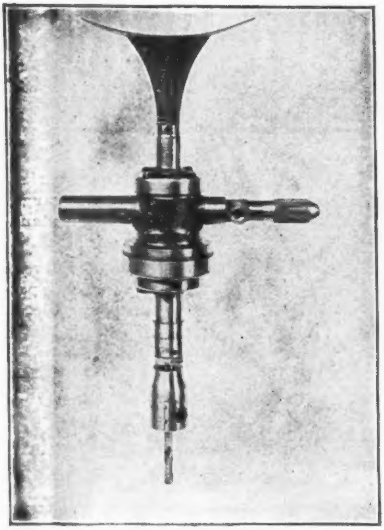

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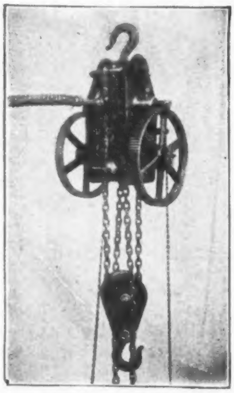

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A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
J. E. QUINTERO, M. E. VARIAN, } Associates

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We have received a letter from one of our English readers, which is given in full elsewhere in this issue, because it discusses in an interesting manner the subject of mechanical valves for small air compressors and gives the views of an English manufacturer of this class of machinery.

In this our correspondent says:

"But few of us will agree with the statement made in it (referring to an article discussing mechanical and poppet valves) that the clearance in a good mechanical valved compressor need not be more than one per cent., though in small compressors it is usually the practice to allow greater to save expense."

Continuing he says: "But it is not necessary to do so if expense is not of first importance." Very true, and there is no theoretical reason so far as we know why a small compressor cannot be made with as small a clearance as a larger one. But there are many practical difficulties which, while capable of refinement, we must admit that the experience of a large number of manufacturers shows that they do exist. Take, for instance, a fairly large compressor with cylinders from 16 to 36 inches in diameter and strokes from 24 to 48 inches. These engines run at slow speeds and are capable of close adjustments. The clearance in this type of engine is invariably small. In fact, we know of one manufacturer who finds it necessary to adjust piston rods to allow for expansion when they become heated, so small is the clearance allowed.

In these large compressors, speaking relatively, the port space and clearance due to ports and valves openings is less than is possible in the small sizes. Whether this is the result of necessity or not, the fact remains and manufacturers in general will admit this statement. Why is the clearance greater in small compressors? We think that cost of manufacture and the same reasons applying to any small machine fit in here. A small electric motor, for instance, is never as efficient as a large machine, a small steam engine uses more steam than a larger one, and a small boat does not have the speed that a larger one can show. Questions of strength and facility in manufacture also play their part.

However, no one for a moment claims that a very efficient and satisfactory small compressor cannot be made. Proof to the contrary exists in our correspondent's letter if such were needed.

Further on, in referring to the adjustment of mechanical valves, he says: "There is not the slightest fear of closing too late or too early if the valve is properly set."

This is freely admitted in the article which he is discussing. The size of the

"if" in this case is the point on which part of the argument against mechanical valves hinges, and the experience of a great many has been that the right instant to close or open an air valve is a variable factor very difficult to locate. With small compressors a fixed slide valve similar, for example, to the Weiss system, in extensive use abroad, serves very well; but we never see, at least on this side of the water, this type of valve employed.

We observe that our correspondent admits the fallibility of indicator cards, and that they are not always proof positive of the perfect working of an air compressor cylinder. They certainly are not, and the matter of slip or leakage past the piston is more often the cause of the compression line following the true, isothermal curve than is the efficiency of the jacketing. Indicator cards, like the prophesies of the oracle of Delphi, are capable of a double interpretation and should be taken *cum grano salis.*

The article to which our correspondent refers was not intended to condemn all mechanical valve compressors. Its purpose was rather to sound a note of warning which would prevent mechanical valves becoming a fad without proper investigation.

Referring to his conclusions, we must say that they should draw from the manufacturers of compressors using, in part or as a whole, poppet valves some of their reasons for adhering to a type of valve which, so far as we know, is considerably more expensive than the slide valve or other forms of solidly moved valves.

We trust that others of our readers favoring both types will discuss this subject, which is perhaps the most important connected with air compressors.

James F. Lewis.

There died at Boston, Mass., on July 23d last, this man of worth whose taking off has thrown the pall of sorrow over many homes. We mourn the loss of one whose heart was always touched by others' cares, whose thoughts were ever keen in aiding friends. In such a selfish world as this, where wealth, and greed, and gain are kings, 'tis pleasant here and there to meet a man who conquers self, and such a man was this. 'Tis not surprising, therefore, that a flood of tears fall fast upon his grave. Tears from friends of high and low degree. The rich and poor were all alike to him.

Mr. James F. Lewis was born at Blandford, Mass., May 26, 1840, and lived there until he was about fourteen years of age. From there he went to Bloomfield, N. J., returning to Westfield, Mass., after his marriage in 1862.

He enlisted at the first call in the Civil War and was in the Third Connecticut Volunteers and was wounded at the battle of Bull Run.

He went into the firm of Rand, Lewis & Rand, manufacturers of whips, etc., at Westfield, and was there for several years. About 1876 he went to Amenia, N. Y., as superintendent of The Manhattan Mining Company, and in 1881 he moved to Quinnimont, W. Va., as superintendent of a mining company there. He left Quinnimont and joined the Rand Drill Company early in 1884.

In 1892 he went to Chicago to manage the Western business of the Rand Drill Co. He was elected president of the Canadian Rand Drill Company in 1890.

He was a member of many societies and clubs, among which are A. S. Civil Engineers, A. S. M. E., Canadian Mining Engineers, The Engineers' Club, and the Lafayette Post of New York, A. I. M. E., Western Society of Engineers, British Iron and Steel Institute, the Technical Club of Chicago, Republican Club of New York, N. E. Society.

Mr. Lewis held the love of his friends and the admiration and respect of his opponents in business. He was a salesman of exceptional ability, and he played an important part in the building up of the business of the Rand Drill Company.

The frontispiece of this issue is a fine example of photography, which also affords an excellent idea of the way the drilling of submarine rock is carried on in our harbors and rivers.

The equipment illustrated is intended for places where there is a considerable rise and fall of tide, where currents are encountered and where the water overlying the rock is deep.

The picture shows the pontoon and the framing in front, on which is mounted in slides two rock drills which are operated by steam obtained from a boiler in the house at the back of the pontoon. The mast standing up above the framing is used to raise the long drill steels which are necessary in deep water. This outfit has two 5" drills and is at the present time at work in Boston Harbor, Boston, Mass., removing a ledge which juts out into the main ship channel.

The contractor for this work is Mr. C. W. Johnston, through whose courtesy we obtained the photograph from which our illustration was prepared.

"Railroad Tunnels, Their Construction, Maintenance and Operation."*

This paper was prepared solely and purely from the construction point of view, and with no regard whatever to operation.

The subject of the "Construction of Tunnels" is divisible into a great number of classes. From the point of view of construction tunnels built for sewers, aqueducts or mines or for railroad service are identically the same.

A tunnel proper, presupposes by its name, that it is an underground passageway constructed from *within*, without breaking the surface of the ground. Those works, however, commonly called tunnels, which are constructed from the surface by methods of "cut and cover," are, properly speaking, "subways," but since in the public mind they are classed as the same thing and as the resulting use of the completed work is identical, I propose to class such subways as are constructed for railroad service in cities as though they were tunnels and give a brief explanation of *their* methods of construction also. This, you will see, is the more necessary since there is hardly any complete subway which has not had some portion of the work constructed as tunnel, as the constructing engineer finds is best adapted to the local conditions and to economy in construction, and the two classes are so closely interwoven as to be inseparable in practical execution.

Speaking first of subway construction, the simplest condition is that in which the geological formations give solid rock or some hard, self-supporting material in which to work—in which the surface has no buildings closely adjacent which would preclude free use of dynamite to break up the materials and in which there are no street cars, or pipes, wires, or other sub-surface improvements to be considered or taken care of. In this case the work is usually laid out to full width for the external lines of the permanent linings, and either blasted and picked down or channeled by drilling the side lines and the entire center core blasted out working it in benches, one in advance of the other, the number depending entirely on the depth to bottom grade. These ideally simple conditions are

* **Abstract of a paper by Mr J. V. Davies, read before the New York Railroad Club.**

seldom found in practice, for if rock exists below the surface it usually has a heavy bed of loam or sand overlying, and in cities the interference by surface improvements is very serious and complicating; and it is the presence of these surface and sub-surface improvements in cities which makes subway construction in rock formation so enormously expensive.

Under these conditions it is easier and cheaper if the formation is found to be in clay, dry sand, dirt or other softer material than rock, which can be picked and shovelled, as there is then no danger of injury to the pipes, which require only ample support for maintenance in perfect safety. Under these conditions the usual method necessary to adopt is to take out side trenches one on either side of the construction in which to construct the side walls. These trenches are supported with sheet piling or timber in every way similar to the methods used in our cities in sewer construction.

In the construction of a portion of the Reading Subway, in the city of Philadelphia, the loose soil was supported and maintained by driving sheet piling on either side of the trench, the trench being made wide enough for the extreme bottom width of the wall construction. The sheet piling was cross-braced and supported by string timbers and cross-ties or spreaders, and the material excavated usually by pick and shovel to the depth of the bottom of foundations.

In this method of construction there are used sundry machines, such as the Carson Trench Machine, or the Lidgerwood Company's Machine for handling the material rapidly and economically and saving labor, but the essential principle common to them all is the excavating of the material, while at the same time maintaining support to prevent caving of the sides. This is a perfectly simple piece of work, involving no difficulties of any moment, and certainly not more so than the difficulties found in excavating any foundation for buildings in the same neighborhood.

With the side walls constructed, it is a perfectly simple matter, involving merely labor, to excavate the central block or core between, as was done in building the subway under the Andrassy Strasse in the City of Buda Pesth.

In the Reading Subway, in the city of Philadelphia, recently constructed, the side walls were completed and the roof formed of the segmental arch.

The construction of subway in this manner by excavating side trenches first, and later taking out the core, reduces considerably the liability of accident and damage over the plan of taking out the full width at once, in cases where that width is of considerable dimension. If the width of subway to be constructed is great, as it is in cases where double-track railroad and standard-gauge cars are to be used, then the cross-timbering requires to be very heavy, and the handling of this involves a great deal additional labor, which is materially reduced in the narrow trenches, made of timber.

In the construction of those portions of the subways in the city of Boston, which were built from the surface, it was usual to carry the street traffic on a false floor made of timber.

In this work in Boston a considerable amount of the construction was done as tunnel built from within, without breaking the surface of the street.

Of course this method of subway construction becomes more difficult if quicksands or running sands are met, and is always considerably more expensive where large volumes of water require to be dealt with. In those cases the construction in this form is liable to become very much more expensive than the construction in tunnel, as the methods peculiarly adapted to tunnel construction in cases where water or running sand is encountered are not feasible in construction of an open cut.

The question as to whether a tunnel should be built by methods of cut and cover or from within as tunnel depends partly on local considerations of soil, but principally on the relative quantities of material to be moved and the relative cost of removal of the classified excavation. This is commonly equal at a depth of about 40 feet from the surface to bottom grade, although in the construction of the Blackwall Tunnel in London it was found advantageous to build the approach on the Kent side of the river in open cut and cover down to a depth of about 70 feet below surface.

The essential condition in tunneling is the support of the face, sides and roof at all times and under all conditions. It is comparatively easy in the exercise of care

and forethought to prevent any *commencement* of caving, even in the very worst materials in which tunnels can be constructed; but if ever any bad ground once gets a start at moving or caving, then hardly any power on earth can stop it.

In railroad construction the greater proportion of tunnels are built in rock formations of one sort or another. Outside of tunnel construction under rivers and waterways or under the streets of cities these are constructed usually for one of two causes. Either to cross from one water-shed to another through an intervening line of hills or to cut off curves on a line of road to shorten distance and improve alignment. The ideal condition is one in which the rock formation is absolutely self-supporting. The heading is usually driven from 50 to 100 feet in advance of the removal of the bench to full cross-section. The size of this heading depends on the size of the completed tunnel. If it is a tunnel for a single-track railroad the heading is usually the full width of the tunnel, while the height will be about eight or nine feet and the removal of the single bench in the rear will take out the entire tunnel to the full section required.

The construction of the tunnel is carried on by drilling either by hand or machine drills, and these holes are driven like a letter "M." The lines of holes forming the center "V" are known as the "cut." While the straight legs on the sides are known as the "side round."

The cut holes after drilling are the first ones charged with powder, which is put back as near to the point of the "V" as possible. When this is exploded the central wedge is blown out of the face, and the shooting of the "side rounds" then straightens up the section, and gives the resulting net gain in heading driven, a little short of the depth of the cut holes.

In cases where a tunnel is short in length and the expense of installing a power plant would not be warranted by the length of tunnel to be constructed, then it is usual to use hand power for drilling, but in all cases where the tunnel is of considerable length and the distribution of expense due to the cost of plant over the entire tunnel forms reasonably small item, then this installation is of the greatest economy to the contractor, and the greatest efficiency in carrying out the work. Under these conditions air pressure is almost entirely used in conjunction with percussion drills and if the rock is unusually hard, it is nowadays essential to install this method even if the tunnel is short, as hand drilling in hard rock is slow and expensive.

The taking out of the heading in all these rock tunnels is the expensive part of the work. The removal of the bench is the cheaper work which brings down the cost of the tunnel as a whole. It is, therefore, obvious that the construction of a small-sized tunnel in rock is yard for yard more expensive than the construction of a double-track railroad tunnel, but there is a point in matter of size below which it is not in any way advantageous to go. The width of a tunnel must be sufficient to get an angle of cut such as to allow of blasting out the rock and if the width is decreased in a rock heading below this point there is no economy to be gained.

There are large numbers of rock tunnels, however, which are constructed in seamy rock, or in shales which disintegrate, or in which "falls" occur which at times endanger the work and make construction difficult. In these cases it is essential to timber every bit of the tunnel as it is taken out for the support.

The explosives used in rock tunnel work are an important factor. Dynamite long ago displaced black powder. Now the "gelatines" are pushing dynamite hard.

Tunneling in soft ground introduces more complications.

The principle then involved is to drive a heading in advance of final tunnel construction which is so small that the ground will not cave in until the workmen can put in timber or plates to support it. Once having the heading driven, the same principle applies for the enlargement. For as each small portion of the completed section is taken out, timbering or plates are put in place to support the ground from caving, until the entire section has the excavation removed, leaving an opening consisting of a mass of timber supports vertical, horizontal, and in every direction, with poling boards or plates of light sheet-iron supporting the external surface, inside of which the permanent lining can be constructed, after which the supporting timbers or struts can safely be removed.

An arrangement used in the Hudson River tunnel is to drive a small heading

consisting of a pipe of light sheet steel called a "Pilot Tube," connecting its plates together internally by bolts, piece by piece. From the outside circumference of this pilot tube are strutted the poling boards or plates for the external full section, which necessitates the use of much shorter struts than the long ones which are necessary with the use of a "mud sill."

In the construction of the portion of the subway recently completed in Paris, a good deal of the work was excavated by driving narrow headings or tunnels on each side of the street in which were constructed the side walls of the completed tunnel. The same plan was adopted in portions of the Boston subway, and in both of these cases there was used an arching shield to support the superincumbent ground while the roof of the tunnel was being constructed.

The most difficult branch of tunnel construction is obviously that in ground which is so treacherous that it is unsafe to use any of the foregoing methods of construction. In such materials as quicksand, or water-bearing soil, or in decomposed schists, or under other conditions, there is no safe, feasible way of construction but by use of pneumatic pressure in conjunction with hydraulic shield; and there is no method as rapid in progress or as safe in execution as this.

The use of air pressure permits of the support of the ground and the checking of the flow of water by equalizing the pressure within, with the superincumbent weight of the ground. In order to use pneumatic pressure the installation of an air lock is necessary. The air lock consists simply of a cylindrical tank or boiler with valves or doors at each end, opening in the same direction, that is inwards against the pressure. The illustration

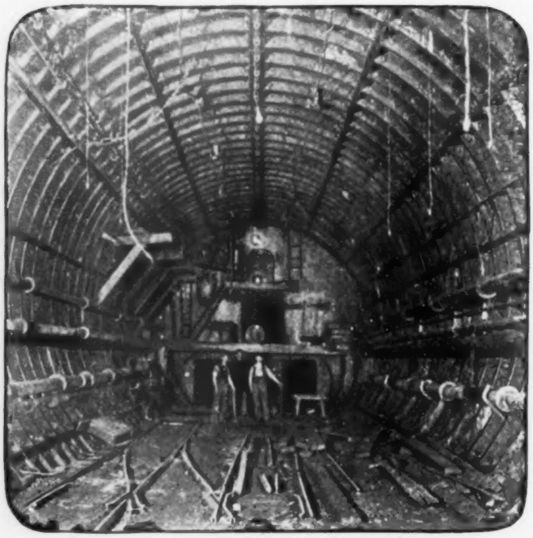


Fig. 1.

(Fig. 1) of the air lock installed in the Blackwall Tunnel under the Thames in London, indicates two air locks on the working deck, which are used for the supplying of materials and for the ordinary use of the employees.

In addition to this, there is placed near the roof of the tunnel a third lock, which is known as the "emergency lock," and is for the use of men in cases of possible flooding of the tunnel when the lower lock might become submerged. The driving of tunnel is by use of hydraulic shield, and the two illustrations now to be

given are of the front (Fig. 2) and rear (Fig. 3) portions of the shield which was used in driving the Sarnia Tunnel under the Detroit River, between Canada and the United States.

The principle involved in the use of a shield is the support of every portion of the face, the roof and the sides of the tunnel, until permanent lining is completed and in place. As will be noticed, the shield consists of a bulkhead divided into sections, or compartments, and each compartment fitted with doors. In front of these compartments the men employed excavate as much of the section as they can possibly take out and this amount depends upon the solidity and condition of the ground.

As each portion of ground in advance of the shield is removed, the hydraulic jacks in the rear are forced out, pushing the shield forward to take up any advance which is gained in excavation.

As the shield is advanced the length of a ring of plates, that is, from 16 to 24 inches in length, a new ring is erected in the rear of the shield bolted up and the shield is then again ready to push itself forward, using the pressure of the rams against the already completed length of lining and advancing another section to permit of the putting in of yet another ring of plates.

A completed section of this type of tunnel is illustrated (Fig. 4) representing the

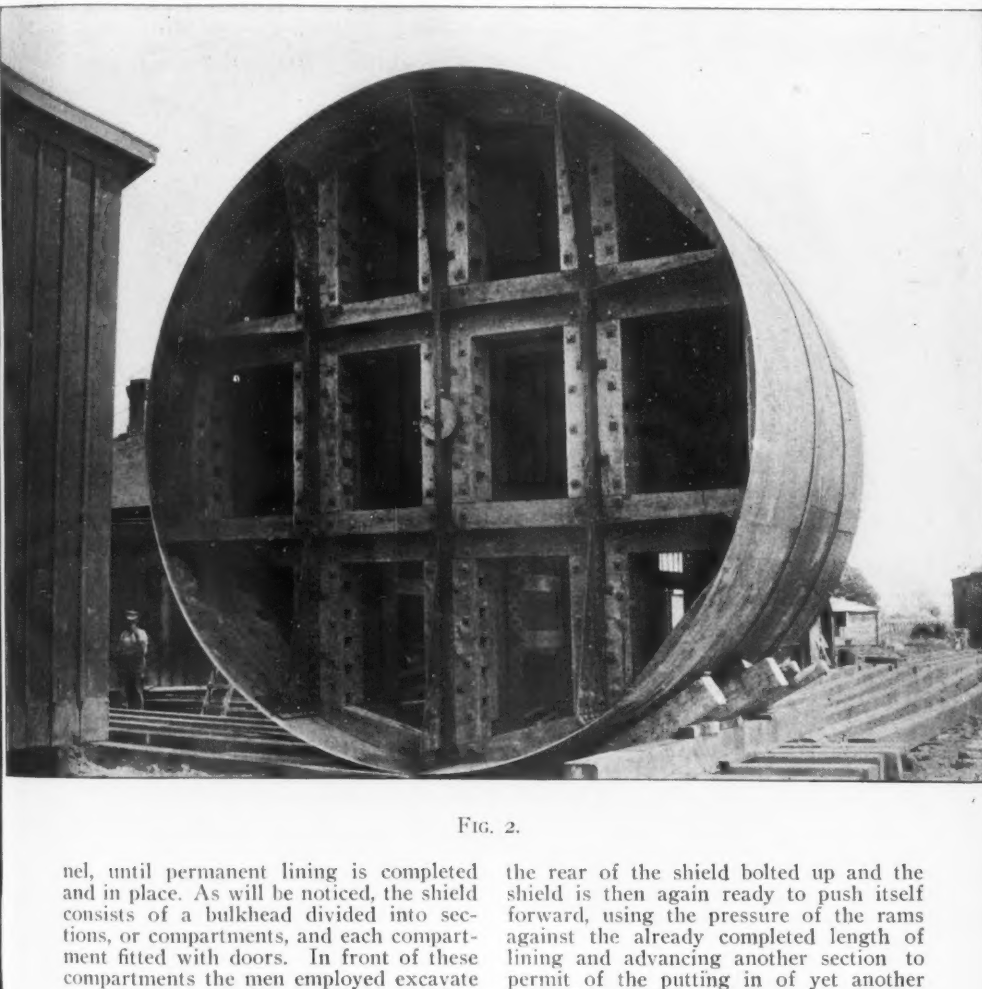


FIG. 2.

East River gas tunnel, which clearly shows the rings of segmental plates bolted up and completed, forming a cylindrical tube of cast-iron which is impervious to water and of great strength as well as durability.

In the construction of tunnel by shield method the erection of the shield is the first necessity, and there are three conditions under which this is usually carried out. In the Blackwall Tunnel driving was commenced from an immense vertical shaft 58 feet diameter, sunk near the river front. In this case a circular hole is left in the lining of the shaft and from which construction proceeds.

The second method which was used in the Sarnia Tunnel where a great open cut approach was dug from the surface and the shield rolled down into place to commence tunnel construction.

The third condition was that adopted in the East River Tunnel where the erection had to be done by making an enlargement in the tunnel itself, which was supported during erection of the shield, and the shield built up in place piece by piece underground and under air pressure, and driving started from that point. This is the most awkward condition, and involves the greatest difficulty owing to the cramped space in which men can work.

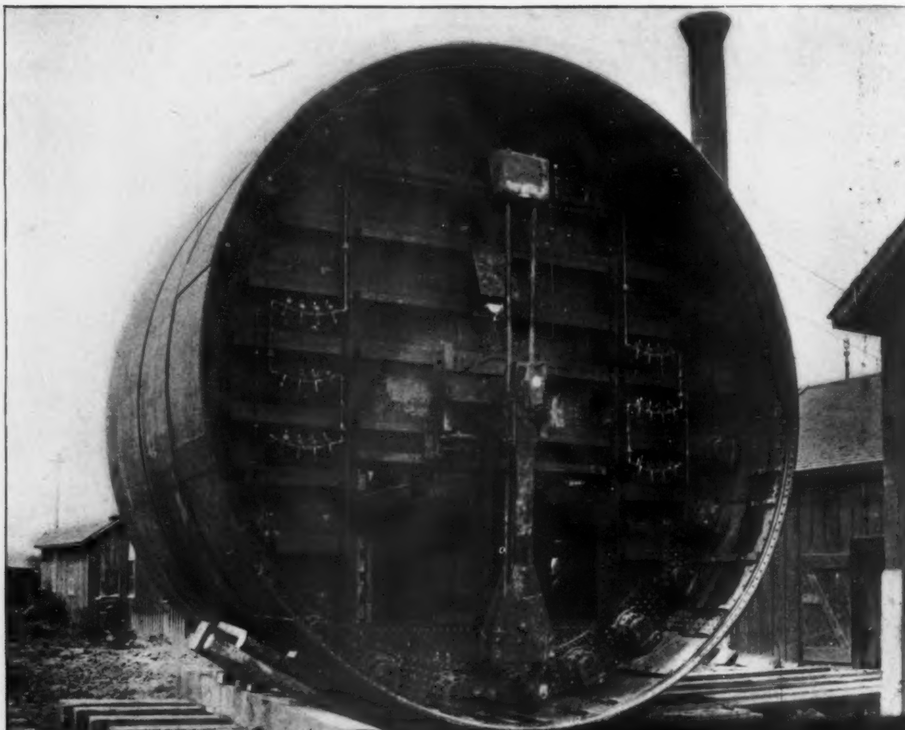


FIG. 3.

Tunnels are lined with various materials. If it is built in rock formation and cut stone is obtainable, then very commonly cut stone masonry is used for the side walls, and cut stone or brick for the arching. If good brick is obtainable then the arching can be more substantially put in of brick in cement, while the side walls can be built of stone, but where good

Fig. 4.

Portland cement and good hard rock is to be had, there is nothing more satisfactory than concrete lining throughout for both side walls and arches. The greatest secret in good, permanent, substantial lining of tunnels is the thorough and efficient *packing* of all space and crevices in the rear of the lining itself, and the bad packing in back of masonry is the cause of most of the trouble which the roadmaster has in the maintenance of his railroad tunnels.

In that respect the use of concrete for the entire lining is extremely advantageous, for in that case the centers or moulds forming the internal surface of the lining are the only ones used and the concrete is rammed to fill every space clear back to the construction timber or to the original ground itself, and the benefits resulting therefrom are very great. If the material through which tunnel was constructed is bad and liable to disintegrate, then it is essential (even with the use of masonry or brick face lining) to ram concrete in the rear of it to fill all cavities and to prevent any commencement of caving of the ground, which is invariably the source of trouble originating in tunnel work.

At the time that we constructed the East River gas tunnel at Seventieth street, we had at one time an opening right through to the waters of the East River. We ran the pressure up to fifty-two pounds per square inch, and worked under that pressure, while tomato cans and rubbish of all kinds came right into the tunnel from the river bed. The safety of tunneling by shield methods, and with the use of compressed air, was illustrated in the Blackwall Tunnel in London, where the largest iron-lined tunnel ever built, twenty-six feet internal diameter, was driven within five feet of the bed of the river with perfect safety. They had, of course, great difficulties to contend with; but the tunnel was built and is now in operation.

Notes on Coal Cutters.

The conditions under which coal must be mined are at best unusual and extremely difficult on man and machine alike, and there are certain prime or principal operations necessary in this work which cannot be modified no matter how much we may desire to do so. For instance, our coal veins are variable in thickness, always underground, surrounded by a hard material, frequently inclined at very steep angles and nearly always so formed that timbering must be used. The work must be conducted in confined spaces where the air at best is never good, and where there is ever present the danger of explosion due to fire damp. In addition to these general difficulties, there are others of local nature and still others resulting from the character of the labor employed.

The ordinary miner at best makes no pretensions at being a mechanic or knowing much about machinery. The result of all this is that a machine to operate in a coal mine must first of all meet the physical conditions and then the human factor which is frequently the most difficult. Both of these mean that a coal cutter must be light, it must be simplicity itself, so that it can be understood and operated even by the ignorant. It must be durable, strong and capable of running with practically no attention. It must be free from all complications liable to accident or requiring skill for examination or repair; it must be capable of producing a paying result. In other words, after the price of the machine is considered the cost of power to operate it, the cost of maintenance and every other factor of this sort is added, the output resulting from the machine must then be sufficient to cover all of these items and leave an ample margin.

Now various types of machines have been developed for mining coal, but in general, these may be classified under two headings; those considering the conditions as they now exist in mines and imitating as far as possible certain methods of excavation which long experience has shown to be most satisfactory and effective. The second system constituting a radical departure and consisting of a machine not adapted to the conditions encountered in mines and actually requiring that the mining conditions be modified to meet its wants.

Further, the second class of machine even in its simplest form is heavy, cumbersome, most complicated and expensive in first cost and in cost of operation and repairs. It cannot be operated by the same class of labor, as the man in charge of such a machine must know something about electricity or engines. The use of these machines is limited to very few

places where the conditions are unusually satisfactory. Two machines must be used where shearing is to be done—one for undercutting and one for shearing. The number of men required to operate such a machine is greater than with a simpler form. It cannot be used in restricted places, and entry driving must be done entirely with the old hand method.

If the electric form is used there is constant danger to the workmen, and a still greater danger of explosion. A fall of roofing is apt to damage the machine beyond all possibility of repair in the mine, necessitating its removal to the surface.

Idleness is ruinous to the electric machine. The sulphurous or acid gases always present in a mine rapidly deteriorates the insulation and corrodes connections. In case of the machine becoming wet it is practically ruined, for water and perfect insulation are ever antagonistic.

OPERATION OF THE "NEW INGERSOLL" COAL CUTTER.

On the other hand, we have the Puncher machine consisting of a cylinder, front head, back head, piston rod, valve chest and wheel. Weighing about one-quarter of what the other type does and with no delicate working parts of any sort, and what few operating pieces there are, so absolutely covered and protected as to preclude injury from the outside.

This puncher machine is so simple that the ordinary run of mine workmen can understand it and operate it safely from the start. It takes up considerably less room than the other machine and requires less power to drive it and permits the operator to see exactly what is being done and allows him to guide and direct the work the same way as he guides his pick, thus making the output proportional to the man's own exertion and not dependent upon the whims of a complicated machine.

The air enters the cutter through a flexible rubber tube connected with the main throttle on top of machine and passes through a channel into the interior of the governor valve which, when opened, allows the air to then pass into the valve chest, in which move the auxiliary and main valve. These are cylindrical or spool valves which have attached to their middle suitable flat valve blocks, and these as the valves move back and forth open or close the proper passages. One of these valves throws the admission of air under pressure to the front or back end of the operating cylinder, and this directly controls the movement of the piston.

The second valve is an auxiliary and it controls the operation of the main valve. This auxiliary valve is shifted back and forth when the exhaust opens to the main cylinder and the air as it passes into the ends of the small cylinder, must go through the adjusting valves which are within easy reach of the operator. By means of these adjusting valves, the runner can regulate the rapidity of movement of the auxiliary valve making it go slower or faster as he pleases. When the auxiliary valve shifts, whether slowly or rapidly, it immediately opens a passage which allows the air under pressure to operate the main valve, and this in turn admits full pressure to the piston. The result is that no matter how slowly the auxiliary valve shifts the main piston when it does move, moves out with a full and powerful stroke. This permits the operator to cut down the speed or the number of blows per minute, but the power in each blow is in no way diminished.

This is especially desirable in cutting around sulphur balls or in backing out to finish a cut or in starting up. Of course, the operator can close the throttle partly and reduce the speed, but at the same time he reduces the force of the blow.

In ordinary operation it is not possible to have the pick strike the coal at every blow, and there are times when for two or three strokes the pick misses. In the ordinary form of puncher when a miss oc-

curs the piston shoots forward to the full length of the stroke and meeting no resistance, its full energy is expended in cushioning against the front head with a resulting reaction which makes the machine jump and recoil against the operator much to his discomfort. This also causes a certain amount of delay because this recoil necessarily deranges his aim.

In the new Ingersoll cutter a special automatic regulator valve is provided which has a passage leading to the front end of the cylinder. When the pick misses and the piston shoots forward, the increased velocity causes the piston to pass the main exhaust port and the air is consequently compressed higher than it normally is in cushioning. This increased pressure raises a small valve, permits the air to pass to the regulator or governing valve and instantly shuts off or reduces the main air supply and consequently removes the pressure from the back end of the piston.

The result of all this is that the piston instead of giving a reactive kick, is reversed in direction as smoothly and easily as an engine piston. The instant the rapid advance of the piston ceases the governing valve opens and the normal action of the machine begins again.

Close to the front and rear heads are ports which are closed by special valves, and control that portion of the cylinder which is given up to cushioning to bring the piston to rest at either end. Some distance from the heads are other ports which are closed by the piston when cushioning, but admit full pressure as soon as the piston is reversed by the cushioned air.

If for the moment we regard the piston as returning after a blow against the coal, it will be seen that the air is allowed to exhaust through the inner port until the piston closes it when that portion of the air remaining in the cylinder is compressed to form a cushion. This compression continues until the inertia is used up and the piston comes to rest when the elasticity of compressed air starts the piston in the reversed direction. It continues to move forward until the pressure of cushioned air is reduced to that of the main supply, when the cushioning valve opens and allows the main pressure to enter the cushioning chamber.

Thus the working pressure is maximum for the full stroke and the actual amount of air admitted to the cylinder is perhaps one-third less than it would be with the ordinary form of inlet port. This arrangement results in a very great economy and small consumption of air, and in addition, balances the action of the piston so nicely that the reaction of the machine whether cutting, or should it miss the coal, is unusually small. Realizing that these machines are to be operated and frequently meddled with by the most ignorant class of men, every part is made unusually solid and is arranged so that it cannot possibly be put in any but the right place should the machine be taken apart and put together again. For instance, the main valve has a hole drilled in one end and the cap which closes the valve chest has a corresponding pin. This cap also has a dowel pin which fits into a corresponding hole on the valve chest. Now if the operator goes to put the cap on the valve chest, he tries one side and finds that the pin won't fit, then he tries the other side and finds that it fits properly and the dowel brings it into place, so that the bolts and everything else fit in properly. The same is true of every piece, so that the machine can be assembled in the dark by a person who has never seen it before quite as satisfactorily as by a machinist.

J. J. SWANN.

Discussion of Mechanical Versus Poppet Valves for Air Compressors.*

The article in your useful little paper upon mechanically moved valves will, I expect, be criticised by a good many designers of mechanical valved compressors, but few of us will agree with the statements made in it. The clearance in a good mechanical valved compressor need not be more than one per cent., though in small compressors, it is usually the practice to allow greater to save expense, but it is not necessary to do so if expense is not of first importance. Thus, the loss at 60 lbs. per square in. compression is 5 per cent. of free air compressed, or say, 2½ per cent. more than in a lift valve compressor.

I have the pleasure to hand you a diagram taken from a very small mechanical valved compressor of 8" dia., and 12" stroke, running at 200 revolutions per

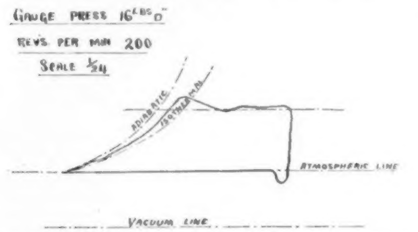
* A letter received from Dewen Hall, Trevor, Llangollen, North Wales.

minute. The adjustment of a mechanical valve gear is extremely simple and can be left to any fitter of ordinary intelligence.

There is not the slightest fear of closing either too late or too early if the valve is properly set.

It must be remembered that the valves, both inlet and delivery, close at end of stroke. Also that the effect of 1° of revolution of crank pin, either past end of stroke or before end of stroke of piston, can scarcely be measured on stroke of piston. Again, the slide valves are moving with their maximum velocity at this point, thus 1° of revolution of eccentric shift makes a great difference in stroke of valve, and very little in stroke of piston. Thus, it is possible to get the point of closing of valve with almost any degree of refinement, and that, without trouble, I have set some dozens personally. The opening of valves either inlet or outlet are not so important.

Of course, the valves must close near end of stroke, but a little study of Indi-



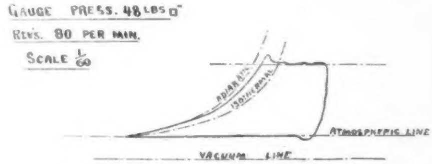
AIR CYLINDER 8" DIA. X 12" STROKE, FITTED WITH THE "HUGHES" PATENT CORLISS VALVES.

cator cards of mechanically valved compressor would show that it does not affect diagram. If the slide valves are allowed to over travel slightly, also allowing a little negative lead, it is possible to keep the inlet valve full open from ⅜ stroke to about ¾ stroke of piston, after this the slowing of piston is so rapid, the gradual closing of valve will not increase the velocity of air through ports. The paragraph as to strains thrown on to valve gear through sudden drop of pressure in receiver does not apply to the European types of Corliss valves for air compressors, as the valves are driven through Oldham coupling, which allows valve to move in any direction except that of revolution. The valves fit their cases and cannot be thrown off their seats. Thirdly, the pressure behind valves cannot change suddenly as is assumed, owing to the fact that the valves fit their cases.

I guarantee that of two compressors of equally good design the one poppet valved and the other mechanical valved, the final temperature would be less in the mechanical valved compressor. In Poppet valved compressors there must be an amount of slips of at least 5 per cent. In mechanical valves this is nil. In Poppet valved compressors the speed is two-thirds to half that usual with mechanical valved compressors.

Thus, leakage past piston in a compressor that has been running for a year or two would be much greater, as the leakage is inversely proportional to square of number of revolutions. The slip and leakage together may thus be anything from 5 to 30 per cent.

It is thus absurd to talk about the small extra clearance in mechanical valved compressors, or the slightly greater final temperature, due to less cooling area when



AIR CYLINDER 9" DIA. X 14" STROKE, FITTED WITH THE "HUGHES" PATENT CORLISS VALVES.

other losses and also the increased final temperature may in poppet valved compressors, make such insignificant. As has been ably pointed out in your paper from time to time, explosions in air cylinders are more often due to leaky valves and pistons and slip past valves than to any other cause.

Summing up,

(1) Mechanical valved compressors are much safer and less liable to explosions.

(2) After a few years' wear and tear they are far more efficient.

(3) The cylinder is completely fitted with cool air during inlet stroke.

(4) The compressor can be run at double the speed.

(5) The compressors are perfectly silent in running.

(6) The compressor per cubic foot of compressed air delivered is far cheaper in first cost.

In reference to latter, my firm make both and find size for size the mechanical valved compressor is slightly more, but per cubic foot air delivered, it is much cheaper. Slide valves, in my opinion, are as important on the delivery stroke as on the inlet stroke to prevent slip and leakage and thus increase safety of compressor. Yours truly, J. A. COOMBS, A. M., I. M. E.

Mechanical Traction in Paris.

COMPRESSED-AIR TRAMCARS.

The application of compressed air to tramcars has undergone a good deal of extension in France since the first line was laid down at Nantes in 1876, but it is in Paris that the system has recently been making most progress in competition with other forms of motive power. Compressed-air vehicles have special advantages of their own which render them particularly suitable for certain conditions of traffic. They can be compared with accumulator cars for independence and silent running, and have none of their drawbacks except weight. They possess the elasticity of power of the steam vehicles, and have none of their objections on the score of exhaust and the handling of fuel. Compared with the trolley, the compressed-air cars are equally capable of overcoming great resistances, and they do not necessitate the laying down of overhead or surface installations. In a word, from the point of view of the public who do not care for unsightly installations, and prefer silent cars that are not soiled by products of combustion, and can be relied upon to travel at a good average speed, compressed air would seem to be an ideal form of power for tramway vehicles. But unfortunately, the public are not alone to be considered, and as the companies must get the best results out of their lines, they find that the comparatively high cost is only justified under special circumstances. Theoretically, it would seem as if the cost of compressed-air cars ought to be lower than those with accumulators, and more economical even than steam, because while the weight of air compressed by a pound of coal is only about three-fourths the weight of steam produced with the same quantity of fuel, the consumption of air in the motor vehicles is considerably less than steam. But as we shall show further on, the actual results do not work out so well in favor of compressed air.

The reason why the Compagnie Générale des Omnibus has given a preference for compressed-air cars on some of its lines is that it does not want any overhead or surface-contact installations, and that owing to the conditions stated above, they fulfil the requirements of the Parisian public more satisfactory perhaps than any other system of independent vehicle. The first compressed-air line in Paris was laid down between Saint-Augustin and the Cours de Vincennes, and the system was also subsequently employed for service between the Louvre and Versailles, while recently the Compagnie Générale des Omnibus has substituted compressed air for horse traction on the line between Passy and the Hôtel de Ville, La Muette and Rue Taitbout, Louvre and Saint-Cloud, Louvre and Boulogne, Auteuil and the Madeleine, and Montrouge and the Gare de l'Est, representing a total length for the whole system of 57¾ miles. The fact that the system should have undergone such a development is sufficient proof that, apart from its advantages as a *quasi* independent vehicle, it must be an economical success. It is true that this economy is only relative, and for a long while after the first line was constructed there was a good deal of controversy as to whether any advantage was to be gained commercially by employing compressed air instead of other forms of motive power. Experience, however, has shown that the economical results can be improved by fixing upon a certain ratio of compression in relation to the special requirements of the line and in working several radiating lines by means of one central power station. In the early days of compressed air, this question of compression was a very serious problem. As the loss of power augments with the increasing difference of pressure in the air reservoirs and the engine, it would seem as if every advantage would be gained by using a low compression, so that there would be no necessity for considerable expansion before admission into the cylinder. This was the method advocated by M. Popp, who believed that the best results would be obtained by using pressures of 210 lb. to 280 lb. per square inch, and frequently re-charging along the line. But these frequent stoppages would not only mean loss of time, but a further expense in laying down

mains, and the energy stored up might not be always sufficient to overcome any special resistances. M. Mékarski, on the other hand, started with a pressure of 420 lb. at Nantes, and increased it to 590 lb. at Nogent, 480 lb. at Saint-Augustin-Cours de Vincennes, and as much as 1,120 lb. per square inch on the line from the Louvre to Boulogne and Versailles. This rapid progression shows that M. Mékarski was right in his contention that it is preferable to use high pressures to enable

FIG. I—COMPRESSED AIR CHARGING POST.

the vehicles to cover long distances without re-charging. Such a result, however, has only been rendered possible by the peculiarities of the Mékarski system, which compensates for loss of power through reducing from high to low pressure between the reservoir and the engine by maintaining the temperature of the air both before admission and during expansion in the cylinder. Before M. Popp started to apply compressed air to tramcars, there was naturally a difficulty in overcoming the exceedingly low temperature due to rapid expansion in the cylinder. The cylinder soon became covered with ice, and the lubricating oil froze. M. Popp raised the temperature of the air before admission by passing it through a spiral of copper tubes in a coke furnace on the vehicle, and in this way he not only doubled the efficiency by a higher expansion, but raised the final temperature of the air. M. Mékarski went still further. He quadrupled the efficiency by raising the temperature of the air before admission and also during expansion in the cylinder, and this, too, by a device that was much more simple and far less cumbrous than the coke furnace of M. Popp. He simply passes the air through hot water, when it becomes saturated with steam, and on being admitted into the cylinder the steam gives off its heat to the air, and serves the double purpose of securing a greater expansion and preventing the final temperature from falling to a low point. It is this device which has rendered the compressed-air car practicable, and brought the efficiency up to something like the theoretical limit.

Before describing this system of utilizing compressed air, it will be advisable to deal with the installation of the line between Saint-Augustin and the Cours de Vincennes. The compressing plant at La Villette station has been devised by M. Mékarski, who employs the three-stage, or triple-cascade system, which experience has proved to be more economical than the single stage for high pressures. The air is kept at as nearly as possible the same temperature during the whole operation. The compressor, capable of working up to 1,120 lb. on the square inch, is a vertical machine with four cylinders in pairs, tandem fashion, and is operated by a horizontal engine of 80 to 100 horsepower, and running at 100 to 150 revolutions a minute. The diameter of the lower cylinder is 15½ in., and of the upper one 10 in., and the stroke of all four pistons is 12½ in. At the bottom of each of the lower cylinders are two induction valves and one outlet valve, which are kept under tension by springs, and the induction valves carry on their upper faces cups into which water is constantly dripping from a tap. The water overflows the valves, and is drawn up with the air during the upward travel of the piston. The object of this mixture of water is to keep the air at a uniform temperature, and lessen as much as possible the difference between the temperature of the air drawn into the low-pressure cylinder and the final temperature in the high-pressure cylinder. It is for this reason that the air is drawn from outside the building, and it is notorious that in winter the compressors give a higher efficiency than in warm weather. The water being mixed with the air during the upward stroke, is compressed and sent into a first reservoir, 39¼ in. in height and 15½ in. in diameter. The air is taken from the top of the reservoir by the upper left-hand cylinder, which is water-jacketed. The air enters the cylinder by an induction valve at the top, and after compression by the upward stroke of the piston, passes into a second reservoir, 39¼ in. in height and 9¼ in. in diameter. From this second reservoir the air is admitted into the right-hand cylinder for final compression. The next step is to deprive the air of most of the water held in suspension. This is done by passing it through a drying apparatus composed of a steel cylinder, 78¾ in. in height and 23½ in. in diameter. At two-thirds of its height it is divided internally by a diaphragm, which carries a vertical tube, opened at both ends, and extending to near the ends of the cylinder. The air is admitted just below the diaphragm, and passes down around the tube to find a way into the upper chamber. The water gravitates to the bottom, where it is drawn off by a drip tap. Having passed up through the tube above the diaphragm, the air escapes by a port, and is conveyed in mains to the accumulators through the medium of a *déverseur,* or regulator. This mechanism is intended to secure uniformity of pressure in the accumulators, but the pressure can never exceed the limit provided for by the safety valves on the compressing machines and the accumulators. There are two series of pipes going from

the drying apparatus and the accumulators to the charging post, and the two systems communicate with each other, so that the air from the compressors can be sent either to the charging posts or to the accumulators, according to the necessities of the service. When several cars are being charged the pressure in the main from the compressor diminishes, and is then inferior to the pressure in the accumulators. A valve at the junction of the two mains opens to allow of air coming from the battery, and when the charging is completed the valve closes and air from the compressor goes to the battery. There are two regulators which act independently of each other, so that one may be in operation while the other is under repairs. The regulator is situated on the compressor main, and is composed essentially of three parts—a hollow cylindrical plug, closed at its upper end, which separates the compressor main from the mains going to the battery and the charging posts; a small water chamber, and a hollow piston operated by a vertical worm shaft and horizontal wheel. Between the plug and the water chamber is a rubber diaphragm, and the bottom of the chamber is pierced with holes. By screwing down the hollow piston containing air into the water chamber the water is forced through the holes in the bottom, and exerts a pressure on the rubber diaphragm, and consequently on the plug which closes the main. The combination of air and water is intended to give instantaneous action and a very fine gradation of pressure. Its principle will be better understood when we come to describe a similar apparatus on the cars. There are meters above the regulator to indicate the pressures in the compressor and battery mains. The capacity of the batteries of accumulators varies, of course, with the number of vehicles on the line. They are grouped in batteries of five, and each accumulator, constructed of sheet steel, has a height of 8 ft. 2½ in. and a diameter of 23½ in. Each battery is connected up by a pipe communicating with the main, and carrying a safety valve.

The weight of the car without charge or load is 11½ metric tons, that is to say, two tons for the body, which is built to carry fifty passengers, four tons for the reservoirs and heater, and 5½ tons for the underframe and machinery. The most convenient place for the reservoirs would be on the top of the vehicle; but this would mean the suppression of the outside seats, and consequently the reservoirs have to be fitted underneath. This necessitates an increase in the weight of the reservoirs, because they have to be arranged transversely, and several tanks of small capacity have to be used instead of a few large ones, and at the same time the platform of the car has to be raised about 3 ft., thus giving to the vehicle a heavy and unwieldy appearance. Each reservoir is constructed of sheet steel, 12 mm. in thickness, and stamped out with one of its ends in one piece, and the other end is riveted on. The length varies from 47¼ in. to 58¾ in., and the diameter is 23½ in. It is calculated there are 12 kilos. of reservoir for 1 kilo. of air. There are nine reservoirs, arranged in two batteries, one of seven and the other of two, the latter being held in reserve either for helping the car to overcome great resistances or to enable it to proceed to the power station when the energy stored in the other is expended. The reservoirs are constructed to allow of a large margin of safety, and accidents are extremely rare; in fact, we can only call to mind one case of a reservoir exploding on a Paris tramway, and no personal injury was sustained by the passengers. We have referred to the importance of steam as an agent in the Mékarski system for raising the temperature of air before admission and during expansion in the cylinder, both as a means of preventing an excessive drop in final temperature and of securing a higher efficiency. The air is consequently passed through a heater of cylindrical form in the front part of the vehicle. There are separate pipes from the main battery and the reserve battery, each with its own tap, and provided with a pressure gauge, and the air is introduced at the bottom of the heater, where it rises up through the hot water. It is then expanded by a regulator —Fig. 2—on top of the heater constructed upon exactly the same principle as the one already described as communicating between the compressing mains and the accumulators in the power station. The air, saturated with steam, passes up through a valve which is kept under tension by a spring and by the pressure in the heater. The valve has a rod extension carrying at its upper extremity a metallic plate, which is separated from the water chamber by a rubber disc. As in the regulator previously described a worm shaft operated

by a horizontal hand wheel presses down a hollow piston or plunger containing air into the water chamber, and the water, being forced through the holes in the bottom of the chamber, depresses the rubber disc and valve rod and opens the valve. The system is very simple and efficient, and enables the driver to graduate the pressure according to the varying resistances with the greatest ease. The propelling mechanism consists of two single-cylinder horizontal engines bolted on the outside of the frame, with the piston-rods working directly on the rear wheels. The cylinders have a diameter of 7½ in. and the stroke is a little more than 10 in., while the diameter of the driving wheel is 29½ in. It has Walschaërt valve gear, and works with a cut-off of 30 per cent., except under special conditions, as it is found preferable to vary the power by regulating the pressure of air. The reservoirs and engines are protected by outside iron plates, which fall down each side of the car below the frame, and can be raised for inspection.

On the Saint-Augustin-Cours de Vincennes line the profile is very severe and the traffic heavy, and it may be regarded as one of the most difficult lines to work in Paris. As on all the mechanical tramways, the cars have fixed halts and there is no intermediate stopping. In comparing compressed air with steam, we alluded to the smaller consumption of energy stored in air reservoirs, and the reason for this is easily explained by watching the pressure gauge of a compressed-air car. To overcome the inertia of such a heavy vehicle about 200 lb. pressure is required at starting, and after sufficient momentum has been obtained, it is kept going on the level with 30 lb. or 40 lb. and on down-grades it, of course, drops to zero. The aim of the driver, therefore, is to carry the vehicle along as much as possible with its own momentum by a series of bursts of speed, and if not hindered by traffic, he is able to get up enough momentum in the first hundred yards to take him to the next halt. This is, of course, an inducement to fast and reckless driving, and an energetic, and perhaps irritating manipulation of the bell as a warning to clear the way; but it is a testimony to the good sense of drivers of other vehicles that they are never disposed to try conclusions in a struggle for precedence with a 16-ton compressed-air car. It is easy to see that thick traffic, especially when met with on up-grades, means a considerable increase in the consumption of energy, but nevertheless the consumption is by no means so great as might be supposed in view of the heavy deadweight of the vehicle. In fact, this deadweight is utilized to a certain extent in the momentum. A vehicle can store sufficient energy at the charging post at La Villette to take it to Saint Augustin and back. The charging post is situated at La Villette because it is about half-way down the line, at the bottom of a very long and steep gradient going up the Butte Chaumont by the Rue Bolivar. We give an illustration—Fig. 1—of this charging post, which clearly shows the method of connection. Two copper spiral tubes, one for steam and the other for air, are carried on horizontal joints to facilitate connections with the heater and batteries. Steam is discharged into the water contained in the heater at a pressure of 7 kilos., which is equivalent to a temperature of 165 deg. Cent. In the winter it is found necessary to keep up the temperature in the heater by means of a small coke furnace, and the regulator is protected with non-conducting material, but when the weather is not too cold, these precautions are superfluous. The time occupied in charging the batteries does not exceed three minutes. At La Villette the air is taken directly from the mains, but in cases where the charging post is a considerable distance from the power station, it is found desirable to build a chamber of masonry under ground containing a boiler and an accumulator, so as to avoid the sudden variations of pressure in the mains when a number of vehicles are being charged at the power station. We have shown that if the weight of a compressed-air car is a necessary evil, the driver manages to get as much advantage out of it as he can, and it is also used in another direction by employing the motor vehicle for drawing two or three cars. In view of the enormous energy stored up in the reservoirs, and the great elasticity of this power, the tractive effort is only limited by the adhesion of the vehicle on the rails. Every other car on the Saint Augustin line hauls a trailing vehicle, and when a great deal of traffic has to be coped with a second vehicle is added, thus making three in all, which is the limit allowed on the Paris tramways. The system is therefore admirably adapted for dealing with

great variations of traffic. The heavy cars necessitate a good deal of attention to the track, and the wear and tear are apparently no small items in the general maintenance. Each rail is, in reality, composed of two rails laid on inverted T-shaped chairs, the vertical piece being between the rails. This keeps the two rails apart to form the groove. The rails are bolted on each side of the chair, and the inside rails are connected by flat ties imbedded in granite. The twin rails are not joined in the same place, but are spaced some distance apart.

All the compressed-air cars in Paris are similar to the one we have already described, but on the Louvre-Versailles line, there are three cars drawn by a special type of motor vehicle. Eight reservoirs are placed longitudinally in the body of the car, and contain air at a pressure of 1,100 lb. to the square inch. The weight of 16½ tons empty, and 18 tons in full charge, is distributed equally over three axles. The wheels are coupled, and the engines are of the same type as in the Saint Augustin cars. Instead of a vertical heater, there are two longitudinal hot-water reservoirs of large capacity underneath the frame, one being used when the temperature of the other has fallen. Their capacity is increased in the same relation as the air reservoirs, which, with their high pressure and large capacity, will allow of the "trains" traveling from the fortifications to the Louvre and back with a single charge. There is a driving gear at each end of the car. To provide for the considerable extension of the compressed-air system the Compagnie Générale des Omnibus has recently completed a large power station at Billancourt. The installation, with a capacity of about 16 tons of air an hour at a pressure of 1,100 lb., is composed of eight compressors, each driven by a horizontal triple-expansion engine developing 1,000 horse-power. The engines, constructed by Dujardin et Cie, of Lille, have Corliss gear, and two of the cylinders are arranged tandem fashion, while the third is placed tandem with the low-pressure cylinder of the compressor. The diameters are 19½ in., 31 in., and 51 in., and the stroke 55 in. The diameter of the flywheel, weighing 15 tons, is 21 ft. 4 in. The compressor has cylinders of 22½ in., and 10 in., with a 22½ in. stroke. Before passing from the second reservoir into the high-pressure cylinder, the air circulates through a spiral of copper tubes surrounded by water. There are two driers to each compressor, and the air is stored in 280 accumulators or receivers grouped in batteries of ten. Each accumulator is constructed of 42 mm. steel, and has a length of 10 ft. 5 in., and a diameter of 19½ in. Great care is taken to purify the cooling water before admission into the compressor, so as to avoid any possibility of deposit. Steam is supplied by Babcock and Willcox boilers. The air is distributed to re-charging posts

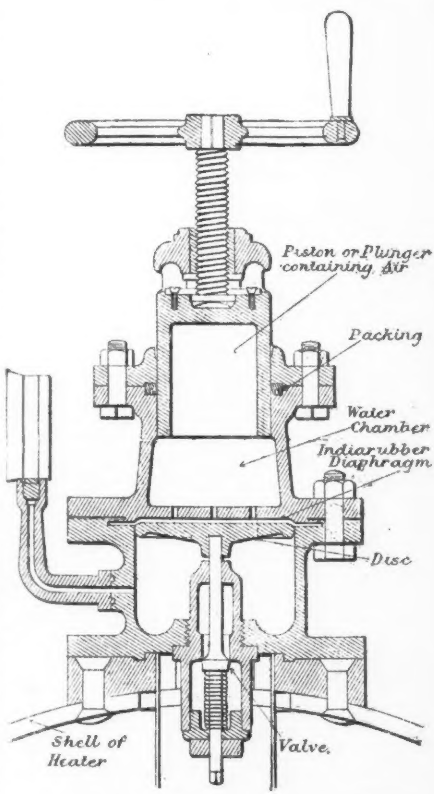


FIG. 2—AIR PRESSURE REGULATOR.

at the Point du Jour, Auteuil station, Passy, and the Port d'Orléans, which is 7 kiloms. from the source of supply. The mains are of lap-welded steel, with diameters varying from 2¼ in. to 4 in., and in

order to reduce the number of joints the pipes have a length of about 63 ft. The joints are made with a couple of triangular flanges separated by a ring of lead and screwed together by three bolts. The loss due to leakage is very small, and is said to be not more than one-half per cent., but it should be remarked that the mains are new, and, except in the case of one of the mains, the distribution is carried on over a comparative limited area.

With regard to the economy of compressed-air traction, it is not easy to arrive at any absolutely trustworthy data, as the figures given are usually based upon solitary tests, and there is a good deal of discrepancy between them. The only body in possession of reliable figures is the Compagnie Générale des Omnibus, and it maintains the greatest secrecy as to the working costs. Nevertheless, it may be said that on the Saint Augustin line the drivers are allowed 14.5 kilos. of air per car per kilometre. They are offered a premium on the air economized, with the result that they make a saving of 25 per cent., so that the consumption of a car weighing, with a good average load, 14 tons would be 10.8 kilos. The cost of producing this quantity of air depends upon the compressing plant, as the expense diminishes in a certain ratio with the increasing capacity of the machine. Upon the Saint Augustin line the total working cost of the compressed-air cars is estimated at 57 centimes per kilometre car, and this is about one-fourth more than steam, and is, in fact, higher than any other of the mechanical systems used in Paris. The working cost is certainly being reduced on the new lines, which are supplied from the Billancourt power station, but it is too early yet to give any idea of the economy effected by a large compressing plant. The extension which has been given to the service shows, at any rate, that the Compagnie Générale des Omnibus is entirely satisfied with the results of the Mékarski system. The utilization of compressed air is, however, not confined to the Parisian tramways, for members of the engineering congresses held in Paris last year were shown some powerful shunting locomotives propelled by this power, the energy being furnished by an installation of Mékarski triple-cascade compressors, which also supplied power for turntables, cranes, and a variety of other purposes.—*The Engineer.*

Machine for Loading Rails, C. M. & St. P. Ry.

The usual method of loading rails, as when picking up old steel where new rails have been laid, is to have a gang of men large enough to pick the rails up bodily and throw them broadside upon flat cars. In times of busy traffic, however, it is frequently the case that flat cars are not available, and consequently gondola cars, or even box cars, must sometimes be used for this purpose. The work of loading rails into gondola or box cars by hand is a tedious operation. A push car is coupled to the rear gondola car by means of a stick of timber, and upon this push car there is a dolly blocked to proper height for shoving the rails upon the car. A gang of men large enough to lift the rail then pick it up, shove it forward on the dolly until it reaches the end of the gondola, where men with tongs grab the rail and pull it forward. In order to handle the rails easily and quickly by this method, about 22 or 24 men are required.

Some months ago Mr. Edward Laas, roadmaster of the company at Elgin, Ill., designed a machine for this work of loading rails which has since been in service on the Chicago & Council Bluffs division of the road. The machine is operated by compressed air supplied by the air brake system of the cars, and the services of a large gang of men are dispensed with. The machine consists of a derrick mounted upon a push car and operated by an air hoist. More in detail, the push car or truck carrying the derrick is 7 ft. wide and 10 ft. long, with a tool box on one end to carry such tools as are needed for the convenience of the work and to counterbalance the derrick while it is being moved. The derrick mast is a piece of 3-in. gas pipe screwed into a plate on one end of the truck and held by stays running to the four corners. The foot of the boom swivels on a pin set in the plate which supports the mast. The boom is 23½ ft. long and consists of two 2½-in. gas pipes trussed vertically with rods passing over the ends of wooden blocks, and braced laterally by rods running over iron struts set against the aforesaid wooden blocks.

The hoisting cylinder is 8 ins. in diam. and 6 ft. long, on the inside. The piston rod carries a 17-in. sheave wheel on a

cross head guided by small wheels running on the two pipes of the boom. Hoisting is done by means of a two-part ⅝-in. wire cable made fast at the end of the boom and passed around the piston sheave wheel, so that for a full travel of the piston the cable lifts 12 ft. The pulley at the end of the boom is 17 ins. in diam. In rear of the mast there is a storage reservoir 3 ft. high and 2 ft. in diam. which is placed in connection with the air brake pipe of the cars by disconnecting the hose between two cars and coupling on in the ordinary manner. This reservoir has a capacity sufficient to lift two rails after the air from the train has been cut off. The hoisting cylinder is operated by means of an air cock. The end of the boom stands 19 ft. above top of rail, and when rails are being lifted the end of the derrick truck opposite from the derrick is held down to the car by means of two adjustable hook clamps attached to a beam running crosswise the truck and set to catch the under sides of the side sills of the car. The derrick is designed to lift a load of 1,500 lbs.

In handling rails the derrick truck is run to one end of a flat or gondola car and clamped in position for loading upon the adjoining car. As each car is loaded the machine is pulled back one car at a time, small gang planks being used to bridge the opening between the cars. The machine can be pushed over the cars by five men, but in usual practice it is pulled by cutting the train one or two cars back of the machine and attaching a rope to the last car coupled with the locomotive. As will undoubtedly occur to the reader, one great advantage in the use of the machine is that it may be operated to load a whole train of empty cars without the necessity of shifting. As it is unnecessary to run to a side-track to switch any of the cars, the machine can therefore be worked all of the available time.

In loading rails six men are required, and the usual practice is to pick up the section gang where the rails are to be loaded. In the distribution of this force, there is one man at the air cock (usually the foreman), two on the ground to attend to the lifting tongs and to prevent the rail from swinging; and three on the car, one of whom handles the lifting hooks and the other two swing the rail to place, while the man handling the air lowers the derrick cable. While the work of loading is in progress the boom is stayed to one side of the gondola or flat car so it will not swing too far out. When a rail is lifted the boom is swung by merely swinging on the rail. After some experience, it has been found that the most convenient device for attaching to the rail is a single pair of tongs at the middle.

When laying new steel on double track it is the practice on this road to throw the old rails into the space between the tracks, so that with this machine the rails can be loaded with the work train standing on either track. When loading the rails into box cars they are first lifted on to a flat or gondola car and then run into the end of the box car on a series of dollies placed at an incline. As is obvious from the illustration, the machine can be used just as conveniently in unloading rails as in loading them.

As a matter of record this machine has loaded 65 rails in 30 minutes. The cost of labor in loading 608 rails, or 18,240 lineal feet, of 75-lb. rail, on one occasion when the work was interrupted by running to sidings to clear for trains, was $8.75, or less than 1½ cents per rail.

Several of these machines are to be built by the Chicago, Milwaukee & St. Paul company for use on other divisions of the road. The new machine will be built after the pattern described, in which the wheels come inside of the side sills of the truck, where they are out of the way and cannot catch the side of a gondola car when being hauled over the train.—*Railway and Engineering Review.*

Air Pressure in the Oil House.

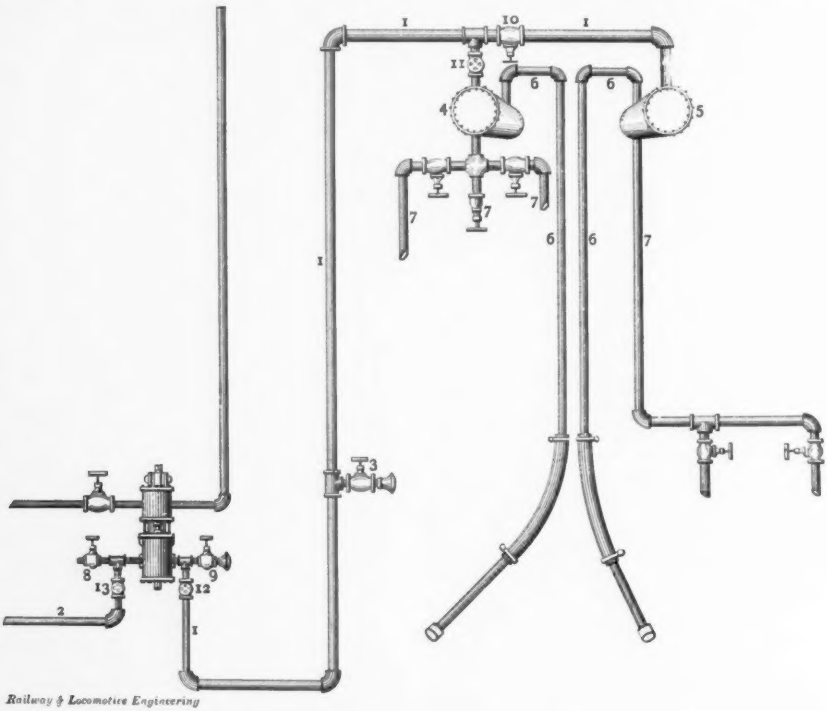
I am sending you, under separate cover, an invention of my own for transferring oil out of barrels into tanks, which at a glance will very nearly explain itself.

The reservoirs 4 and 5 are the ordinary air reservoirs used on locomotives and will hold about 80 gallons of oil. The suction pipe 1 from pump is cut into top of reservoir through globe valve 11. I can cut the suction into reservoir 5 by closing globe valve 11 and opening globe valve 10, or *vice versa.* In order to get oil in reservoirs 4 or 5 I start pump to work. To relieve the pump of pumping against the air pressure that is already pumped up in the main air reservoir, I

close globe 13 and open globe 8. This opens pump discharge direct to atmosphere. Then I close globe 9, open globe 12 and close 3. This gives me a direct pull through whatever reservoir I have cut in up through suction pipe 6. down in barrel through bung hole. After the barrel is empty I open globe 3. This allows pump to get air from this point while you are emtying oil from reservoir through globe 7.

I use 5 for light oil and 4 for dark. The three globes under main reservoir 4 are 1¼-inch drain pipes and keep the oil to a temperature that it will run nicely, I do not find any need for the addition.

It takes just 75 seconds to empty a barrel of headlight oil, and 3 minutes for the other oils. There is no danger of any oil getting in suction pipe to the pump, as we empty only 52 gallons or a barrel at a time and the reservoirs hold 80 gallons. My air pump is in stationary engine room and is 75 yards from the oil house, with 1¼-inch pipe and connections all the way through. I don't know, but I think I am



AIR DEVICE FOR EMPTYING BARRELS OF OIL.

drain pipes to the car, engine and valve oil tanks. The one under 5 is for headlight and signal oil; so you see, after I get oil into these reservoirs, it is no trouble to get it in the tanks. I could empty it much quicker by turning my air pressure from main drum back in these tanks and forcing the oil out; but as I have making this pump do about as much as possible, with the exception of cutting the exhaust in as a heater for the oil house, which I intend doing as soon as cold weather sets in again.

R. H. Briggs, Jr.,
M. M., Nor. Ala. Ry.

Sheffield, Ala.

Compressed Air Yacht Whistle.

Gleason-Peters Air Pump Company, Houston and Mercer streets, New York, have just put on the market the yacht whistle here illustrated. Fig. 1 shows one example of it for use on naphtha launches, auxiliary yachts and all similar craft when

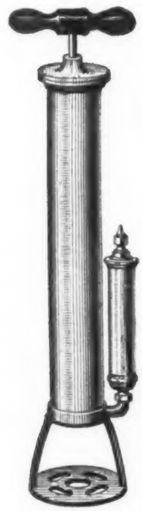


FIG. 1—COMPRESSED AIR YACHT WHISTLE.

it is necessary to blow a whistle or fog alarm; getting the effect of a steam whistle by means of an air pump. These hand outfits are made in a variety of ways, Fig. 1 representing it in portable form, so it can be used anywhere. It has a 16-gauge brass cylinder, 3 x 21 inches, the capacity of which is 150 cubic inches; cast brass cap and socket and detachable galvanized iron foot base that will not rust. All joints are threaded and soldered, and working parts are made of bronze metal. It is known as No. 159. Another style for the same general purpose is designated as No. 160, and illustrated in Fig. 2. The cylinder of this one is 3 x 9 inches, with an air capacity of 65 cubic inches. This outfit is so arranged that it can be readily screwed to the ceiling of a boat, and the whistle can be placed any height above the deck, the whistle being attached to the back of the pump. Still another form, known as No. 214, not here illustrated, can be attached in the same way or screwed to the locker seat, but the whistle is connected to the front of the pump instead of the rear end. Any of them re-

FIG. 2.—COMPRESSED AIR YACHT WHISTLE ATTACHED TO BOAT.

quires but one hand to operate. This company manufacture pumps for all purposes where compressed air is used, including pumps for bicycles and pneumatic wagon tires and numerous other uses in trades, professions, factories, etc.—*Iron Age.*

Garry Pneumatic Cranes.

At the shops of the Chicago, Rock Island & Pacific at Fifty-first street and Wentworth avenue, Chicago, a number of

modern devices are in use for facilitating the work being done, and in a short visit recently to these shops notice was taken of the up-to-date manner in which the work was carried on. Of the devices mentioned, an illustration is given of a No. 2 revolving pneumatic crane, manufactured by the Garry Iron & Steel Roofing Company, of Cleveland, O., and which, according to the workmen using it, is almost indispensable in connection with their work. The crane is used in the lumber yards of the company, and assists in the handling of the heavy timbers and other materials used in the work of repairing and building cars. The crane has been in use for some time in the yards and requires three men for its operation, but, it is said, easily does the work of eight. It is operated by compressed air, and being placed on a car the crane can be moved to any part of the yards desired. The car is provided with four hooks, placed at each of the four corners of the platform; these may be fastened under the rails, tightened, and the car thus firmly secured in any position desired. The workmen operating the machine are well pleased with the work accomplished, affirming that there is no doubt of the economy of the device, it being of special value in the winter when the timbers are covered with snow and ice, making their moving by hand very difficult. The operation of the crane is very simple, one lever controlling the hoisting and another the revolving motion. One man standing on the platform after the material to be moved has been attached can quickly raise and swing it around to any position desired within the radius of the crane. Besides the operating man, one for loading and another for unloading the crane are all that is required for its operation.

GARRY PNEUMATIC CRANE IN OPERATION.

Aside from crane No. 2 machines of both heavier and lighter types are manufactured for correspondingly heavier or lighter work. Crane No. 1, built for heavy work, is of the stationary type, and is especially adapted to the unloading of car

trucks, wreckage and other heavy materials which come into railroad yards. Crane No. 3 is of a light type, and is especially applicable for loading into box cars and similar work where only moderate power is necessary. It is fitted with a pneumatic turntable similar to the larger types of cranes, and when mounted on a truck can be easily taken to any part of the yards or shops, not being restricted to portions in which tracks have been laid. The simplicity of both operation and construction are two of the features claimed for the machines, as well as a great saving in the handling of heavy materials.

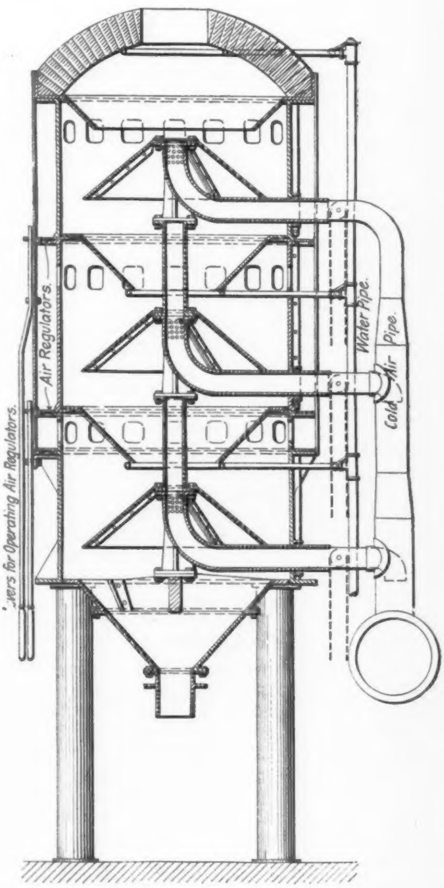
The company also manufacture pneumatic jacks of different sizes for raising cars and work of a similar nature, as well as pneumatic painting machines. In the latter the paint is conveyed through a hose to the brush and is applied by the use of compressed air.

A handsome catalogue, describing and illustrating the various machines manufactured, has just been issued by the Garry company.—*Railway Age.*

A Combined Clinker Cooler and Air Heater.

In one of the cement works in Pennsylvania there has been in use for some months an apparatus designed to afford means for simultaneously cooling the clinker from the rotary kilns and for heating the air used in the kilns. Its general arrangement of parts is shown in the accompanying cross-section. Supported on three cast-iron columns is a shell of three cast-iron cylinders having an inside diameter of 5 feet and a total height of about 9½ feet. The top is covered with a dome of fire brick having a central opening through which the hot clinker from the kiln is allowed to fall directly upon the upper set of hoppers and cones with which the interior of the apparatus is fitted. The object of these fittings is to cause the clinker to roll alternately toward and from the axis of the cooler during its downward passage, thus affording an opportunity for its heat to be removed by the combined action of air and water.

The air is supplied under a pressure of



CLINKER COOLER AND AIR HEATER.

3 or 4 ounces by a blower, which forces it through a pipe having three branches, one terminating in a perforated bend under

each cone. The air escapes from the cooler through openings in the top of each cylinder, just under the hopper resting on its upper inside flange. The outside of the cylinders are encased in sheet steel, provided with handholes through which the hot air can be discharged if so desired. The flanges on the outside of the cylinders have a number of openings which can be opened or closed by moving a flat ring which rests on each flange. This can be done by levers worked from the outside of the cooler. There is also a flue or pipe leading from the shell around the outside duct to the kiln and the apparatus for feeding powdered coal to the kiln.

The apparatus is also fitted with three perforated rings of 1-inch gas pipe for the purpose of spraying water over the clinker at different stages of its passage through the cooler. These are placed so as to be out of the way of the falling clinker, and each is fitted with a valve so that the amount of water admitted at each level corresponds with the purpose it is to accomplish at that point. The water sprayed from the top ring on the clinker just as it comes from the kiln at a temperature of 2,000 to 3,000 degrees Fahrenheit, causes it to disintegrate rapidly, while the sprays from the lower rings not only have a further cooling and disintegrating effect, but are also believed to hydrate the excess of lime and otherwise improve the product. The air forced into the cylinders tends to evaporate the water and remove the steam, the product finally being delivered at the bottom in a dry condition ready for the final grinding.

The hot air and steam from the cooler are used to increase the combustion in the kiln, being admitted either directly into the latter or discharged through the fan that furnishes the blast for the powdered fuel. In this way it is stated that a considerable saving in the coal required for the kilns can be effected, the steam being reduced to a sort of water gas by the hot clinker and thus aiding the hot air in producing improved combustion of the powdered coal. It will be noticed from the drawings that the air can be taken from all three sections of the casing, or if it is not all desired, the upper two or the top alone can be used. One of the main objects of the apparatus being to improve the burning of the clinker in the kiln by furnishing a better air supply than is usually employed, it is, of course, desirable to draw whatever air is taken for the purpose from the upper part of the casing.

This apparatus is in use in the plant of the Nazareth Cement Company, and has there shown a considerable saving in fuel per barrel, according to the superintendent, Mr. Elvin U. Leh. He also reports a material reduction in the cost of grinding to be caused by the cooler, due to the disintegration of the clinker by the action of the steam and water.

The apparatus was invented by Mr. Robert F. Wentz, consulting mechanical engineer, of Nazareth, Pa., who has applied for patents covering its features.—*Engineering Record*.

Air Compression at Altitudes.

The effect of the altitude at which air compressors are to operate is an important matter and often overlooked. The capacity of a compressor in free air, or the volume displaced by its piston, is of course the same under all conditions. As free air, however, varies in its nature with given heights, the amount of compressed air delivered by a compressor under a specific pressure also changes at different altitudes. The barometric pressure of air, usually taken as 30 inches at sea-level and corresponding to a pressure of 14.7 pounds per square inch, owing to diminishing density, decreases with increasing height above sea-level, because the air becomes more rarified. On this account, the efficiency of an air compressor of given capacity measured in the delivered compressed air decreases rapidly as the altitude increases, so that the usual figures made for sea-level do not apply. As the atmospheric pressure decreases, the mean pressure required on the air piston for a given terminal pressure is lowered, so that the power necessary to compress a constant piston displacement of air lessens as the altitude increases. It is found, nevertheless, that the decrease in the efficiency of the air end is at a much faster rate than the decrease in the power required to compress a given volume. On this account, to deliver an amount of compressed air in various altitudes at a certain gauge pressure, which is equivalent in effect to that at sea-level, requires in reality more power than at sea-level.

Altitude in Feet.	Barometric Pressure.		% of Efficiency of Air considering its Volume 100% at Sea Level.		% Increase in Volume Necessary to give at Altitudes Efficiency Equivalent to Sea Level.		Horse Power Req. to Comp. One Cu. Ft. of Free Air at Diff. Altitudes (Single Compression).		% of Power Req to Comp. Same Piston displacement Comp. with Sea Level.		% Decrease in Power Req. to Comp. same Piston Displacement Comp. with Sea Level.		% Increase in Power Req. to Compress the Vol. of air at Alt. which is Equivalent to a given Vol. at S. L.	
	Inches of Mercury	Lbs. per Sq. In.	Gauge.		Gauge.		Gauge.		Gauge.		Gauge.		Gauge.	
			80	100	80	100	80	100	80	100	80	100	80	100
0	30.00	14.75	100.0	100.0	0.0	0.0	.1585	.1800	100.0	100.0	0.0	0.0	0.0	0.0
1000	28.88	14.20	96.8	96.7	3.3	3.4	.1561	.1773	98.5	98.4	1.5	1.6	1.7	1.8
2000	27.80	13.67	93.8	93.6	6.6	6.8	.1536	.1744	96.9	96.8	3.1	3.2	3.3	3.4
3000	26.76	13.16	90.7	90.5	10.2	10.5	.1512	.1714	95.4	95.2	4.6	4.8	5.1	5.2
4000	25.76	12.67	87.8	87.5	13.9	14.2	.1486	.1685	93.7	93.6	6.3	6.4	6.8	6.9
5000	24.79	12.20	84.9	84.6	17.6	18.2	.1464	.1657	92.4	92.0	7.6	8.0	8.6	8.8
6000	23.86	11.73	82.1	81.7	21.8	22.4	.1438	.1629	90.7	90.5	9.3	9.5	10.6	10.7
7000	22.97	11.30	79.5	78.9	25.7	26.7	.1416	.1599	89.3	88.8	10.7	11.2	12.3	12.6
8000	22.11	10.87	76.9	76.3	30.0	31.0	.1391	.1571	87.7	87.3	12.3	12.7	14.1	14.3
9000	21.29	10.46	74.3	73.7	34.7	35.6	.1369	.1543	86.4	85.7	13.6	14.3	16.2	16.3
10000	20.49	10.07	71.9	71.2	39.0	40.0	.1348	.1515	85.0	84.1	15.0	15.9	18.2	18.3

Table (A) for Single Compression at Altitudes.

Altitude in Feet.	Barometric Pressure.		Percentage of Efficiency of Air at Altitudes Considering its Volume 100% at Sea Level. Gauge Pressure.					Percentage Increase in Volume Necessary to Give at Altitudes Efficiency Equivalent to Sea Level. Gauge Pressure.					Horse-Power Required to Compress One cu. ft. of Free Air to Gauge Pressure.				
	Inches of Mercury	Lbs. per Sq. In.	60	80	100	125	150	60	80	100	125	150	60	80	100	125	150
0	30.00	14.75	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	.1175	.1375	.1535	.1708	.1859
1000	28.88	14.20	96.9	96.8	96.7	96.6	96.5	3.2	3.3	3.4	3.5	3.6	.1157	.1345	.1508	.1675	.1820
2000	27.80	13.67	94.0	93.8	93.6	93.4	93.3	6.3	6.6	6.8	7.0	7.2	.1143	.1324	.1481	.1641	.1781
3000	26.76	13.16	91.2	90.7	90.5	90.2	90.0	9.6	10.2	10.5	11.0	11.1	.1116	.1298	.1449	.1607	.1742
4000	25.76	12.67	88.3	87.8	87.5	87.2	87.0	13.2	13.9	14.2	14.6	14.9	.1097	.1273	.1422	.1574	.1707
5000	24.79	12.20	85.6	84.9	84.6	84.2	84.0	16.8	17.6	18.2	18.7	19.0	.1079	.1251	.1391	.1541	.1670
6000	23.86	11.73	82.8	82.1	81.7	81.2	81.0	20.7	21.8	22.4	23.1	23.4	.1059	.1228	.1362	.1510	.1634
7000	22.97	11.30	80.3	79.5	78.9	78.5	78.2	24.5	25.7	26.7	27.4	27.8	.1040	.1203	.1336	.1478	.1598
8000	22.11	10.87	77.7	76.9	76.3	75.8	75.4	28.7	30.0	31.0	31.9	32.6	.1020	.1180	.1308	.1445	.1563
9000	21.29	10.46	75.2	74.3	73.7	73.1	72.8	32.9	34.7	35.6	36.8	37.3	.1003	.1154	.1281	.1415	.1529
10000	20.49	10.07	72.8	71.9	71.2	70.6	70.2	37.3	39.0	40.0	41.6	42.4	.0984	.1133	.1254	.1384	.1493

Table (B) for Two-Stage Compression at Altitudes.

The relation of volumetric efficiencies of air compressors working at sea-level and at altitudes is that,

$$V_2 : V_1 : : 1 + \frac{P}{p} : 1 + \frac{P}{p_2}$$

where, V_1 = volume of free air at sea level,
V_2 = volume of free air at altitude,
p_1 = atmospheric pressure at sea level,
p_2 = atmospheric pressure at altitude,
P = gauge pressure at which the air is delivered.

The comparative efficiencies of sea-level and altitude compressions are given in Table "A" for the common working pressures of 80 and 100 pounds. It also shows the percentage increase in capacity necessary at different heights to be equivalent to sea-level conditions, and the increase in horse powers required to accomplish this result.

At sea level for a pressure of eighty pounds or over, it is advantageous to compress air in two or more stages, but owing to the decrease in atmospheric pressure at altitudes, the number of compressions of the air necessary to attain the required gauge pressure is increased, and it is, therefore, far more economical to compound at such points than at sea-level. For the same reason it pays to compound for lower pressures at altitudes than at sea-level. These facts are becoming more and more appreciated, and to-day for standard working pressures, nearly all compressors of much size installed at altitudes are of the compound type. The accompanying table "B" shows the volumetric relationship at altitudes for a wider range of pressures than given in the former table, and also the horse powers required to compress free air to these several pressures, by two-stage compression.

An illustration of the use of this table is as follows: 1,000 cu. ft. of air compressed to 80 lbs. in two stages at sea-level develops $1{,}000 \times .137 = 137$ H. P. Considering the compression to be at an altitude of 10,000 ft., we note from the table that the volume to be equivalent at this pressure, must be 39 per cent. greater, or 1,390 cu. ft. The H. P. factor for compression to 80 lbs. at 10,000 ft. altitude is seen to be .113 per cu. ft., then $1{,}390 \times .113 = 157$ H. P. is developed under these conditions, or $157 - 137 = 20$ H. P. more than at sea-level is required for the same effect.

The figures for horse powers given in both tables neglect friction losses for which from 10 per cent. to 15 per cent. should be added, depending upon the quality of the compressor used. In connection with the above, it should be borne in mind that steam actuated compressors exhaust into a lower atmospheric pressure at altitudes, which diminishes the back pressure and, therefore, for the same gauge pressure as at sea-level, this causes a gain in the net mean effective pressure obtainable from the steam. This fact should be considered in designing steam-actuated air compressors to work at altitudes.—F. M. HITCHCOCK, S. B., in *The Economist.*

Calculation of Size of Air Cylinder.

I have a horizontal engine, 10 in. cylinder, 18 in. stroke, running 110 revolutions per minute, and want to drive an air compressor to deliver 500 cu. ft. of free air per minute to a pressure of 10 lb. above atmosphere. What size of air cylinder shall I require if the pressure in the steam cylinder is 100 lb., and I work the air cylinder from the piston rod?—PNEUMATIC. *A.*—"Pneumatic" asks for the size of air cylinder to "deliver" 500 cub. ft. of free air. Of course, when compressed to 10 lb. per square inch above atmospheric pressure (24.7 lb. per square inch absolute), the volume will have decreased: also, there will be a loss due to the efficiency of the compressor. The 500 cub. ft. of free air will have compressed into $500 \times \frac{14.7}{24.7} = 297.5$ cub. ft., and the loss due to the efficiency (which may be 85 per cent.) is 15 per cent., so that this 297.5 cub. ft. will still further be reduced to $297.5 \times \frac{100}{85} = 253$ cu. ft. or air delivered into the air receiver or mains. The area of cylinder (in square inches), taking 500 cub. ft. of free air per minute to produce the above volume of air at 10 lb. per square inch pressure above the atmosphere, may be found by dividing it by the piston speed in feet per minute and multiplying by 144. The piston speed is 110

(revs.) × 1½ (stroke) × 2 (strokes per minute) = 330. $\frac{500}{330}$ × 144 = 218 sq. in. = say 16¾ in. diameter of air cylinder. If, however, "Pneumatic" requires a delivery of 500 cub. ft. of air at 10 lb. per square inch pressure, he will require a cylinder proportionately larger.

If 253 cub. ft. are delivered by piston 218 sq. in. area, then

500 cub. ft. will be delivered by piston x sq. in. area.

Hence, $x = \frac{500}{253} \times 218 = 431$ sq. in.

= 23½ in. diam.

As it is desirable to work the steam expansively, the engine must have a heavy fly-wheel, as the steam would be cut-off and expanding at a time when the compressing piston had its greatest load. Also, the power required in the compression cylinder must be developed by the steam cylinder, allowing for the friction of the engine and compressor. To find this power, the mean effective pressure on the compressor piston must be found by the following formula:

$$\text{M E P} = \frac{n}{n-1} p_a \left\{ \left(\frac{p_c}{p_a} \right)^{\frac{n-1}{n}} - 1 \right\}$$

where n = 1.4 when the compression is adiabatic. p_a = absolute pressure before compression. p_c = absolute pressure after compression.

$$\text{M E P} = \frac{1{\cdot}4}{0{\cdot}4} p_a \left\{ \left(\frac{p_c}{p_a} \right)^{\frac{0{\cdot}4}{1{\cdot}4}} - 1 \right\}$$

$$= \frac{7}{2} \times p_a \left\{ \left(\frac{p_c}{p_a} \right)^{\frac{2}{7}} - 1 \right\}$$

$$= \frac{7}{2} \times 14{\cdot}7 \left\{ \left(\frac{24{\cdot}7}{14{\cdot}7} \right)^{\frac{2}{7}} - 1 \right\}$$

= 8.232 lb. per square inch.

With a 23½ in. diameter cylinder and 330 ft. per minute piston speed, this will give 35.7 theoretical horse-power, but as only 85 per cent. of this is actually accounted for at the delivery, and, say, 5 per cent. is required for the friction of compressor piston and rod, the actual brake horse-power must be 90 per cent. of the theoretical horse-power. Ninety per cent. of 35.7 = 32.13 B. H. P. to drive the compressor piston. To get 32.13 B. H. P., the steam cylinder would have to *indicate* about 40 H. P., and the diagrams would have to show a mean effective pressure of 51 lb. per square inch, equivalent to a theoretical M E P of 63.75 lb. (assuming a diagram factor of 0.8), or, allowing a back pressure of 18 lb., 81.75 lb. per square inch absolute. $\frac{81.75}{114.7}$ = 0.7127 = constant (see "Mechanical World Pocket Book," p. 34), and the cut-off in the steam cylinder must be at least 35 per cent. of the stroke, which is very suitable. In this way it is shown that "Pneumatic's" engine is sufficiently large to do the work required, even if the higher capacity is necessary.—Fairfax.——*A.*—"Pneumatic" seems to be laboring under the impression that the steam pressure will determine size of air cylinder. The problem is only one of displacement. Required, delivery of 500 cub. ft. of *free air* per minute. Revolutions of engine, 110; stroke, 18 in. So displacement must be 500 ÷ 220 (strokes) = 2.27 cub. ft. per stroke. 2.27 cub. ft. ÷ $\frac{18}{1728}$ = 236 in. area of air cylinder. This is equal to 17½ in. cylinder and 18 in. stroke. It is usual to allow about 85 per cent. volumetric efficiency. So to actually deliver 500 cub. ft. free air would require air cylinder 21 in. by 18 in. stroke. Volume of 500 cub. ft. free air at 10 lb. pressure = 297.5 cub. ft. Cylinder must be carefully designed to secure least possible clearances. Shall be pleased to give any other particulars.—John Elliott.——*A.*—Air at 14.7 lb. per square inch has to be compressed to 24.7 lb. absolute, or 10 lb. above the atmosphere. 14.7 : 24.7 : : 500 cub. ft. : 840.1 cub. ft. of free air required. Let d = diameter of air cylinder in inches, then $\frac{d^2}{144}$ × 0.7854 = area in sq. ft. With a double-acting air pump we have 220 strokes per minute. Then $\frac{d^2}{144}$ × 0.7854 × 220 × 1.5 = 840.1. By transposition we get d =

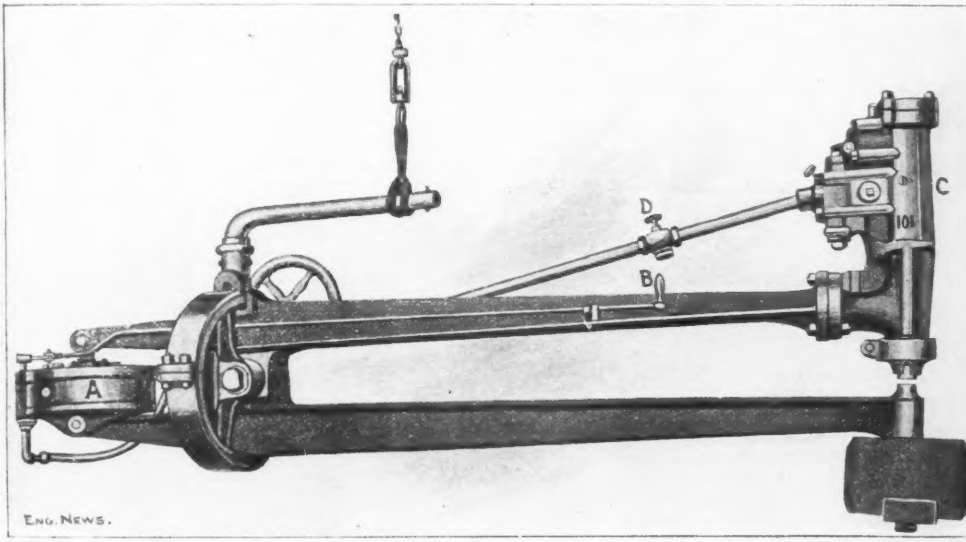
$$\sqrt{\frac{840{\cdot}1 \times 144}{0{\cdot}7854 \times 220 \times 1.5}}$$

= 21.6 in. = diameter of air pump re-

quired. In this calculation no allowance has been made for the area of the pump rod. This rod causes a reduction in the quantity of air delivered, and a slight increase in the diameter of the air pump is necessary to give the required volume.—*Mechanical World.*

A Pneumatic Hammer Riveter with Power Grip.

We illustrate in the accompanying cut a pneumatic hammer riveter for boiler work which has the novel attachment of a pneumatic cylinder for closing the jaws and clamping the work during the heading of the rivet. The construction and operation operator then admits air into the pressure cylinder A by moving the rod B, thereby closing the long ends of the lever arms and pressing the hammer nozzle upon the plates over the rivet. The closing pressure is about 3,000 lbs. Air is then admitted to the hammer C by pressing the spring valve D. The hammer performs the heading operation by a succession of rapid blows—from 150 to 200 per minute. It is stated by the builders of the machine that the time required to form the head of a ¾-in. rivet is about six seconds, and that at steady straight work, allowing for ordinary detention and loss of time, two or three rivets can be placed and headed in one minute. It is also noted that the hammer valve is operated directly by pressure within the cylinder, and is so ar-



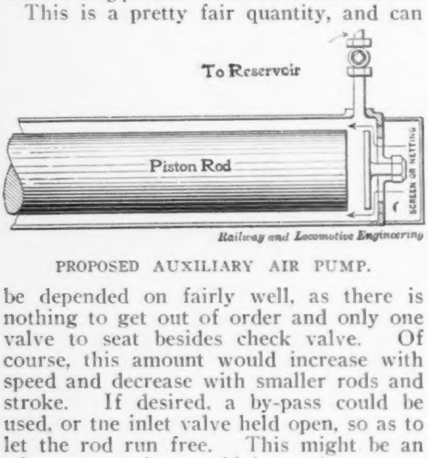
of the macnine are quite obvious from the illustration. Briefly described, the machine consists of two levers hinged together like the blades of a pair of shears, having at one end a pressure cylinder to open and close the levers, and at the other end a pneumatic hammer riveter on one arm and a suitable die, with counterweight, attached to the other arm. To operate the machine, the rivet boy, after inserting the hot rivet, moves the die and weight over the head of the rivet. The ranged that the length of the stroke regulates itself automatically to correspond with the gradual reduction of the end of the rivet, as the head is formed. The hammer is operated under an air pressure of 30 lbs. to 40 lbs. The machine illustrated is built by the Allen Pneumatic Machine Works, 370 Gerard Ave., New York City. We are indebted to Mr. John F. Allen, of these works, for the information from which this description has been prepared.

Auxiliary Air Pumps.

With the increasing difficulty of supplying air for brakes and other auxiliaries, the question of auxiliary pumps is quite an important one. The plan usually proposed is to run the auxiliary from the axle—and it isn't a bad plan, either; but I've another scheme.

Extended piston rods are quite the fashion, and as they don't do anything but puggle back and forth, why not put them to work? No need for any additional packing; just let them work as a displacement pump—single-acting, of course. With a 4-inch rod the area is 12.56 square inches, and with a 28-inch stroke gives 351.68 cubic inches for each piston rod every revolution of the engine. Taking a 60-inch wheel, we have 336 revolutions per mile; or at 15 miles an hour, 84 revolutions per minute. This gives 285.41 cubic inches, or 17 cubic feet, a minute from each rod—34 cubic feet from both rods.

This is a pretty fair quantity, and can



Railway and Locomotive Engineering

PROPOSED AUXILIARY AIR PUMP.

be depended on fairly well, as there is nothing to get out of order and only one valve to seat besides check valve. Of course, this amount would increase with speed and decrease with smaller rods and stroke. If desired, a by-pass could be used, or tne inlet valve held open, so as to let the rod run free. This might be an advantage at times at high speed on a passenger engine. An engine with a 3-inch rod, 24-inch stroke, 70-inch wheel, at 30 miles an hour would give 28 cubic feet a minute.

. This thing works out fairly well, because engines with big rods and long strokes are slower speed, while the small rods and somewhat shorter strokes run faster. The sketch shows the idea, and it will be seen to be very simple.

I'm getting ready to clip coupons from the bonds I expect the railroads will give me for this suggestion. I. B. RICH.

Notes.

For operating air drills, and for mine use generally, compressed air is used at from sixty to eighty pounds pressure to the square inch. There is a tendency developing from practice to use pressures up to 90 and 100 pounds pressure.

Air, at 100 pounds gauge pressure, will leak through a 1-16-inch hole at the rate of over 6 cubic feet of free air per minute; and it takes 1-5 of a horse power to compress this volume of free air, per minute, to a pressure of 100 pounds.

The Howells Mining Drill Company, of Plymouth, Pa., has just sent to the International Mining Congress at Boise City, Idaho, 14 different styles of hand and air drills of the augur type. The Howells Company is now preparing to make electric drills which it hopes to have ready for market by early fall.

The Cleveland Pneumatic Tool Company has opened a New York office at 15 Cortlandt street, in charge of W. F. McGuire, where samples of its complete line of chipping, beading and caulking hammers, the Cleveland long-stroke riveting hammers, piston, rotary and breast drills can be seen.

Two Pedrick & Ayer air compressors are used in a novel way at the Pan-American Exposition for supplying compressed air to a Baldwin locomotive which is to be jacked up off the track and operated in this position. The compressors are compound, automatic, belt driven and will pump the air into the boiler of the locomotive from which it will be used in the cylinders as the motive power for turning the wheels.

The New York Air Compressor Co. and the Franklin Air Compressor Co., 95 Liberty street, New York, have issued an attractive catalogue of air compressing machinery. It contains 48 pages, 7x9 inches, and is profusely illustrated. Considerable attention is given to the points to be considered in the selection and proper installation of air compressors, whether actuated by steam, belt, gearing, electricity, water power or any other source of power supply.

The Standard Pneumatic Tool Co., Chicago, has brought out a new catalogue, "F," 68 pp., 8x11, descriptive of the "Little Giant" pneumatic drills, hammers, reversible boring, flue-rolling, reaming and tapping machines, riveters and other air-using appliances. Many of the illustrations are from photographs, showing exactly what the tools are doing in regular shop practice and exhibit very clearly the advantage of being able to take the tools directly to the work.

The International Correspondence Schools, Scranton, Pa., call attention to the fact that instruction is given throughout the entire year, the vacations of the principals and instructors being arranged so that there is no interruption in the work of the schools. This affords an opportunity for mechanics and others who have a dull season during the summer to take up a course by mail and make good use of what would otherwise be waste time.

At a meeting of the board of directors of the Allis-Chalmers Company in New York on July 3d, $2,500,000 was voted for the erection of a new manufacturing plant at Milwaukee. It was also decided to invest $1,250,000 in a new plant on the Atlantic seacoast for the manufacture of engines and mining machinery for the foreign trade. The company will continue the operation of its two large plants in Chicago, and intends to turn out the bulk of the output of mining machinery there, but will not enlarge its shops in that city.

The Standard Railway Equipment Co., St. Louis, Mo., has recently published a handsome catalogue, describing its pneumatic tools and containing illustrations showing them in operation on various classes of work. The catalogue states that the Monarch hammers made by this company have less vibration and hit a harder blow with a smaller consumption of air than any other on the market; also, that the Monarch riveters, having only two moving parts, the possibility of getting out of order is reduced to a minimum. Full information is also given regarding the capacity of all Monarch pneumatic tools.

One of the latest uses to which pneumatic tools have been applied is chiseling and gouging by means of properly formed tools, used in connection with the pneumatic hammer. The hammer strikes a series of very rapid blows upon the end of the chisel inserted in the hammer, and the chisel is thereby driven rapidly into the block or timber designed to be mortised or otherwise treated. The work is done much more rapidly and with greater ease to the operator than by hand, when using a mallet and hand chisel. The Standard Pneumatic Tool Company, Marquette Building, Chicago, are finding a growing trade in their chiseling hammers designed for this purpose.

A company has been organized to drill an oil well large enough to permit of a man going to its bottom. A daring miner will be equipped with a diver's suit, and will be lowered into the hole. He will examine the various strata of mineral through which the drill passes, and will endeavor to discover the secret of the source of the oil. The investigation is expected to find a reason for oil gushers, and to disclose secrets of invaluable aid to prospectors. The "diver" will carry an incandescent electric light to illuminate the narrow passage. Air will be pumped to him as to deep-water divers. It is expected he will penetrate further into the earth than any man has yet done.

The "Boreas" Air Compressor, which is being introduced by Messrs. Lacy-Hulbert & Co., is of the vertical two-stage type. The main inlet valves are contained in the cylinder head, which is effectively water-jacketed; all the other valves are placed close to the cylinder in separate valve boxes, and are accessible for inspection. They are all interchangeable, and are light steel discs with guides and bearing surfaces. An automatic regulator is also provided for maintaining a constant pressure in the air receiver or air supply mains. In addition to this regulator, a governor is also provided, which acts in unison with the former, so that when no air is being pumped the steam supply is almost entirely cut off, and the engine is just kept running.

The construction of an air cushion rubber pad, so that the cushion is filled with air at each step, thereby breaking the con-

cussion, has been solved by the Revere Rubber Company, Boston, Mass., and 59-61 Reade street, New York. These pads are now on the market, and it is claimed by the manufacturers, that they will cure lameness, keep the horse's feet healthy, and not only increase his speed, but will make him sure-footed on a slippery pavement. The racing pads for trotters, pacers and roadsters are made in 4 sizes, weighing from 3 to 4½ ounces, according to size. They are also made for general use in 12 sizes, from 1 to 7 inclusive, and in sizes and half sizes from 1 to 6 inclusive. These various pads are represented as being for any class of horse, from draft to track horse.

When Professor Dewar's researches at low temperatures first took hold of the popular imagination, certain highly-colored accounts appeared of the possibility of using liquid air or liquid oxygen as explosives—the notion being that the sudden conversion of gases from the liquid into the gaseous form would result at the moment of expansion in an enormous increase of pressure. Such ideas were in the main founded on ignorance of the properties of liquid gases; but it has been found possible by mixing liquid oxygen and liquid air with carbon to obtain a field of practical usefulness for them. The range of usefulness is limited, but a recent account of the cutting of the Simplon Tunnel mentions that in the explosion of blasting charges, liquid air or oxygen has been used with good effect. The charcoal covering of the charge is, shortly before use, steeped in liquid oxygen, and the recovery of the gaseous form has the advantage of mitigating some of the evils the presence of the carbonic oxide tends to produce. Further experiments are projected with a view to making the combustion more perfect, and removing some of the noxious vapors due to blasting.

A novel motor has been designed for the utilization of liquefied air as a motive power for operating a ventilating fan, and the distribution of the vaporized liquid about the room for cooling purposes by means of the fan blades. The globe at the top of the apparatus is used as a storage reservoir for the liquid. To set the fan in motion the valve underneath the reservoir is opened, when the liquid will pass downwards through the pipes, vaporizing by absorbing heat from the atmosphere.

The products of the vaporization will rise through the return coil to the top of the reservoir, where the pressure is utilized to force the liquid continuously into the discharge pipe, in addition to driving the fan. This latter result is accomplished by allowing the compressed vapor to pass downwards through the central tube to a small turbine just above the fan blades, where its force is expended against the wings. As the vapor is of a very low temperature, it is desirable to utilize it for cooling the room after it leaves the turbine and this is accomplished by extending the outlet pipes into the arms carrying the fan blades, where the air is discharged, being driven about by the fan and mixed with the warmer air of the room.

The exhibit of the Chisholm & Moore Mfg. Co., of Cleveland, in the Machinery Building at Buffalo consists of a pneumatic traveling crane of 5 tons capacity and a number of this company's special hoists. The crane is operated by one of the company's recently patented pneumatic switch boards, which enables a person to operate it either from a cage attached to the crane, or from a station on the floor. With this device one person can operate any number of cranes from the same station. The crane on exhibition is supported on I beams resting upon the top of four iron columns 12 feet in height. It is 18 feet in length, and travels a distance of 20 feet. The other equipment exhibited consists of the following: Four pneumatic wire rope hoists of 1½ to 10 tons capacity; 11 Moore differential anti-friction hoists of ½ to 15 tons capacity; 6 direct chain hoists of ¼ to 3 tons capacity; 3 trolleys—one combined geared yoke with a 2-ton block attached, one geared trolley, and one plain trolley; 2 stationary pneumatic motors—one running and one open to show the different parts; 2 pneumatic drills—one of three cylinders and one of two cylinders; 35 American standard rail joints, for tee and girder rails for sections 40 to 100 lbs.; rail and curve braces, malleable castings, etc. The pneumatic crane, hoists, motors and drills are at all times in operation.

According to the *Street Railway Review* of Chicago for May 15th, the elevated railway system of Boston was opened to the public on May 2d, 34 months after the work was commenced. The Sprague multiple-unit system of control has been employed. The elevated tracks have been divided into 85 distinct blocks, the block signals being spaced a distance apart corresponding to one minute in schedule running time—that is, it will take a train at least one minute to run through a block. At each block signal there is an automatic tripping device that will instantly set the air brakes on any train attempting to run past a danger signal. In conjunction with the automatic signals, there are eight switching towers, one of which contains 35 levers and two with 23 levers each. The apparatus at five of the towers will be operated by compressed air. It is probable that each morning operation will be commenced with two-car trains, increasing in an hour to three-car trains. During the morning and evening rush four-car trains will be run at one-minute intervals. In the middle of the day three-minute intervals will be maintained. Trains will operate at an average speed of 30 miles an hour, including stops, but can be run at 40 miles if necessary. From tests carried out, it has been found practicable to attain an average acceleration of 2 miles per hour per second when passing from rest to full speed. Each car is mounted on two Baldwin trucks, and is equipped with two Westinghouse 150 H. P. motors, both of which are carried on one of the trucks, known as the motor truck, the other truck being merely a trailer. This arrangement of the motor and the distribution of the remaining weights bring about 64 per cent. of the total weight of the car and its equipment upon the four driving wheels. The motor truck has 33 in. wheels, the trailer truck 30 in. wheels.

The report of the Bridges Committee contained the following paragraph:

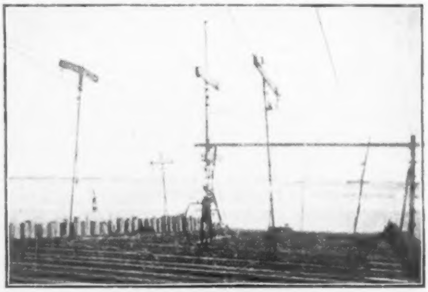
Our attention has been directed to the expediency of experiments being made with the object of eliminating, if possible, the deleterious carbonic acid gas from the air supplied to the Greenwich Tunnel. After careful consideration of various schemes we decided to try the effect of filtering the air through boxes filled with a strong solution of caustic soda, and although the practical construction of the apparatus for this was somewhat difficult to arrange and expensive to work, as the arrangement of the air-compressing machinery necessitated placing the new apparatus in the tunnel, and so, of course, in compressed air, the results have been satisfactory in so far as there has been since the experiment commenced a marked improvement in the purity of the air. Previous to the establishment of the purifier the amount of carbonic acid in the compressed air at the shield, where the men were working, was on the average of nine analyses .148 per cent., as against .047 per cent. in the engine-room, or, say, an increase of 300 per cent.

After the purifier was in operation the percentage of carbonic acid gas at the shield was, on an average of five analyses, .086 per cent., as against .0610 per cent. in the free air of the engine room, or, say, an increase of 34 per cent. We are advised that this very remarkable difference in these two sets of figures is not to be explained entirely by the purifier's action. Differences in pressure, in temperature and character of the men's employment must all be taken into account. Still, the fact that the most favorable analysis of the air before purifying shows an increase of carbonic acid at the shield of 138 per cent., whilst the worst average of the air passed through the purifier gives an increase of 82 per cent., suggest that the experiments are being carried out on the right lines.

The Maine Central R. R. is using the air-pump exhaust to heat passenger trains. A three-way cock is attached to the exhaust pipe, immediately in front of the pump, operated from the cab. The two branches proceed from this three-way cock, one goes to the smoke-box in the usual way, and the other is connected to a carefully jacketed reservoir about 40″ long by 20″ in diameter, hung beneath the cab. The outlet pipe from this reservoir is at the rear end, near the bottom, and is connected to the train pipe by means of a flexible base. The pressure maintained in the reservoir is about 20 lbs. for four cars or less and 4 lbs. additional for each extra car. On some 10-wheel engines on the Maine Central used in heavy passenger service a pressure of 65 pounds has been carried. The question naturally oc-

curs: Is not the pump blocked by this disposition of its exhaust steam; and is there any trouble experienced in maintaining the proper pressure for the brakes? Formerly the only resistance the pump had to overcome was the main reservoir pressure of about 90 lbs. plus the friction. This added to, say 30 lbs. for heating a train of six cars, would increase the resistance. With the common use of a boiler pressure of 200 pounds, this is reported to be a very easy matter. In order to maintain a constant pressure in the reservoir, an automatic relief valve is placed on top of the cab, and set at the desired maximum pressure. It is stated that there is no difficulty in maintaining the brake pressure, nor is there much, if any, difference in the time required to heat by this system and the ordinary method. No trouble is experienced in the quantity of steam supplied on local trains with many stops, as on such a train the pump is constantly working. On long through trains in zero weather it is sometimes necessary to supplement the exhaust steam from the pump with some drawn direct from the boiler. A pipe connection from boiler to reservoir is made, having on it a reducing valve, so that if the pressure in the reservoir sinks below that at which the reducing valve is set, steam from the boiler feeds in. It will be noticed that the live steam is only introduced to supplement that supplied by the pump, and in this way the economy due to the use of exhaust steam is maintained up to the full limit of the pump's capacity. The Economy Car Heating Company, of Portland, Me., is handling this device.

We illustrate herewith a very interesting application of a rock drill operated by compressed air or steam as employed by Mr. R. Palmer, Jr., Noank, Conn., in the construction of a large car float. In these floats a very large amount of lumber is used and on account of the weight of the car load and its peculiar distribution, the greatest rigidity is necessary. In the construction of these it is usual to run longitudinal bulkheads the entire length of the float. In the example illustrated herewith, the float is 285 ft. long and has 6 bulkheads 10 feet high built of 8" yellow pine. These are locked together by long vertical bolts run down through from top to bottom. Driving these bolts is quite an operation, as hundreds of them were used and it was necessary to employ some means to expedite this work and reduce its cost. The scheme finally adopted is well shown in the cut. Six steel cables were run from end to end of the float exactly over the bulkhead locations and roller carriers were mounted on these cables. From the carriers a pneumatic drift driver was suspended by



means of a block and fall. The driver consisted of a rock drill mounted in a frame with an anvil at the bottom on which the drill piston strikes. In use the device is swung over the bolt to be driven, and the anvil is placed on the head of the bolt. When air or steam, as the case may be, is turned on, the drill starts up and the rapid blows quickly drive the bolt. The apparatus rests on the bolt and follows it down, being guided by the two operators.

It was found that two men and one boy could drive all the vertical bolts on this float in far less time and at considerably less cost than could be done by any other means. The same arrangement has also been employed in the construction of dry docks.

We are indebted to Mr. R. Palmer, of Noank, Conn., for the illustration and the information from which this description was prepared.

An ingenious mechanism for obtaining a supply of compressed air for use in air brakes has been devised by Andrew J. Brislin, of New York City, and the broad patent obtained thereon has been assigned to the Standard Air Brake Co., also of New York, which has been recently acquired by the Westinghouse Air Brake Co. The invention relates to that class in which the pressure of air is supplied by

a pump actuated from the axle of a car, and the novel mechanism resides more particularly in means for automatically relieving the pump from its work when the air in the reservoir has obtained a sufficient pressure, and again throwing it into operative relation when the air falls below the proper point of pressure. In constructions which have heretofore been patented, clutch mechanism has been employed between the pump and the operating means, but in the present instance, the pump is continuously operated, and mechanism is employed for opening the pump valves when a predetermined point of air pressure has been obtained. In the construction shown in his patent, the pump is attached contiguous to one of the car axles, and is operatively connected thereto by means of a suitable gearing. From this pump a supply pipe leads to an ordinary reservoir that is connected in the usual manner with the air brake mechanism. The inlet valves of the pump are in the nature of sliding check valves, and directly below them are located sliding plungers that have stems adapted to engage and raise these valves from their seats. These plungers are mounted in suitable chambers that are in communication with a pipe leading from the reservoir. A spring-pressed governor valve is interposed in the pipe and is in open communication with the compressed air reservoir. The operation is as follows: Assuming that the air pressure in the reservoir is below normal, the governor valve will close the communication between the pipe leading from said reservoir to the pump. As the pump is operated, air will be forced through the supply pipe into the reservoir until the predetermined pressure is reached, whereupon this pressure, acting upon the governor valve will open the same, and allow the compressed air to flow from the reservoir into the chamber in which the plungers are situated. These plungers will therefore be raised, and, as a consequence, the inlet valves of the pump will be raised from their seats. In this condition, the air drawn by the pump plunger through the inlet orifices will be expelled through the same upon reciprocation, so that no more air will be forced into the reservoir until the pressure falls below normal. When this occurs, the governor again closes communication and the operation is repeated.—*Railway and Engineering Review.*

A compound air-compressor, drawing in 2,000 cubic metres (70,633,170 cubic feet) of air per hour and compressing it in two stages to 5 atmospheres (73½ lb. per square inch), in cylinders fitted with Köster patent valve-gear, was erected at the Emscher pit of the Kölner Bergwerks-Verein at the end of last year, and has given every satisfaction. The steam cylinders are 475 mm. (18½ in.), the low-pressure air cylinder is 60 cm. (24 in.) and the high-pressure air cylinder 38 cm. (15 in.) in diameter, while the common stroke is 75 cm. (2 ft. 6 in.) and the maximum speed 85 revolutions per minute. The air is first compressed in the large cylinder to 2 atmospheres (nearly 30 lb. per square inch), cooled down in an intermediate receiver, and then further compressed in the small cylinder to the above-named pressure. Air-compressors fitted with positively-actuated valves have the advantage that, as their working is more certain than those with self-acting valves, they can be run at a higher speed, so as to afford a higher duty; and in the Köster arrangement the dead spaces are reduced to a minimum, so that the volumetric yield is as high as possible. The slide-valves, one for each cylinder end, driven by an eccentric on the main shaft through a system of rods and levers underneath the bedplate, are so moved that they shut off both the suction and pressure space at the end of each piston stroke, and open directly the next stroke begins, so that the air can be drawn in and compressed during the whole stroke, being regulated by the pressure in the delivery pipe. With this arrangement if it be asked why back-pressure valves, four for the large and two for the small cylinder, are also provided. *Glückauf,* which publishes in its number for May 25 the drawings of this compressor, replies that such valves are of great advantage, as they prevent the compressed air from passing back into the cylinder from the delivery pipe, so soon as the return stroke of the piston begins and connection is made by the slide-valve between the cylinder and the pressure space, which return with consequent re-expansion of the compressed air would uselessly absorb a not inconsiderable portion of the power exerted. With back-pressure valves, on the contrary, it is only the air between this valve and the piston slide-valve that passes back into the cylinder; and, as its

quantity is slight, the loss of power is also slight. In order to still further reduce this loss the piston is arranged to continue its stroke a little after closing the passage, thus drawing through the back-pressure valve the air in front of it, which action also causes a very soft closing of this valve. The trials made with the compressor on its being taken over from the makers, Pokorny und Wittekind, of Frankfurt-Bockenheim, showed that its actual performance exceeds that guaranteed.

Book Review.

The Design and Construction of Oil Engines, with full directions for Erecting, Installing, Running and Repairing. By A. H. Goldingham, M. E. $5\frac{1}{4}$ x $7\frac{1}{2}$ ins., 196 pp. Price $2.00, illustrated. Spon & Chamberlain, Cortlandt St., N. Y.

This is a brief but practical and useful little book on oil engines in which the author makes no effort to treat the subject in an exhaustive manner.

Theory and mathematics are omitted, and only material of practical value for draughtsmen, those contemplating the use of oil engines and engine attendants is included.

The list of chapters comprises such subjects as testing, cooling water, oil engines, driving dynamos, oil engines connected to air compressors, water pumps, instructions for running, repairs, etc. Various useful tables are given, and all in all, the book is a valuable collection of information relative to oil engines.

"Tunneling." A practical treatise by Charles Prelini, C. E. D. Van Nostrand Co., 23 Murray St., this city; $6\frac{1}{2}''$ x$9\frac{1}{4}''$, 150 diagrams, 312 pages. Price, $3.00.

We have examined with great interest this excellent work on "Tunneling" and are free to say that we think it one of the best treatises on the subject which has appeared.

The authors have made no attempt to cover the subject in an exhaustive way, because there are a number of books which go into the details of the subject in a very complete manner.

As stated in the preface, the book owes its origin to a series of lectures which the author has been in the habit of delivering to the students in civil engineering at Manhattan College. Numerous additions and modifications have been made in these, and the whole incorporated in the volume to which reference is here made.

The treatment is logical and surprisingly comprehensive, considering the small size of the book. The text is clear and well written and the illustrations excellent. A careful selection of material has been made so that the reader when he puts the book down, has a very fair knowledge of the subject of tunneling. The authors have made an effort to include information of a practical nature, as well as matter of general interest, such as average costs, etc., and other information which makes the book of value to the practical man as well as to the student. We recommend this work, and would advise engineers who have to do with tunneling, to secure a copy.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

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1. Is it safe to use common engine oil (black oil) whose base is petroleum, for the lubrication of air end of air compressor, compressing air to 120 lbs. to the square inch?

2. Would you recommend pure flake graphite for air end of compressor?

3. Is graphite better than oil as a lubricant for air compressors, cylinders for all pressures?

ANSWERS.

In answer to the first question, we cannot do better than to refer to COMPRESSED AIR, Volume V, No. 9, November, 1900, in which this subject is discussed.

The question of lubrication of air compressors, cylinders, is, however, important enough to warrant a brief review.

Only the best grades of cylinder oil should be used, and in every case care should be exercised to keep the valves free and clean. Oil should never be allowed to accumulate in the discharge passages and receiver. Especially is this

true where compression is carried as high as 120 lbs. per square inch.

All oils have a certain flash point or a temperature at which the oil will ignite spontaneously.

This flashing or burning depends upon the presence of oxygen. In an air compressor cylinder, therefore, it is seen that the conditions are favorable for an explosion if the oil is at all volatile, for the compressed air is rich in oxygen and is heated to a temperature sufficiently high to ignite the volatile element.

All that is needed in a case of an inferior oil with a low flash point is a proper mixture of air and volatilized oil to bring about an explosion. Any oil rich in petroleum, gasoline, or benzine properties is not a good oil for compressors.

Flake graphite is not suitable for an air compressor cylinder for the reason that it cannot be readily introduced into the cylinder, is apt to cake and clog passages, gets under valves and prevents their closing, and on account of its character, falls to the bottom and will not lubricate the top of the cylinder.—EDITOR.

SIRS—I am still greatly indebted to you for your useful little paper which I note is increasing in the number of its pages, and also in importance.

I venture to send you a letter criticising an article on Mechanical Valved Compressors which appears in your current number. In air compressors, I fancy you will find some of our makers up to date on this side of the Atlantic, notwithstanding the opinion expressed in our London *Times* in reference to compressors at Paris exhibition, which you reprinted. There are hundreds of makers of compressors in this country, in fact, nearly every foundry in the country makes compressors to order. But it is only the few specialists with whom it would be profitable to compare notes. Yours faithfully,

J. A. COOMBS, A. M., I. M. E.
Llangollen, North Wales.

Q. 1. What is the first cost and cost of installation of an air compression plant, per H. P., as compared with electricity, and what are the comparative weights per H. P.?

Q. 2. What is the comparative cost of pipe and properly insulated wire?

Q. 3. How do the repair bills compare?

Q. 4. Of course, in underground work, air would help the ventilation of a mine, and in case of accident might be the means of saving life. What other advantages does it possess?

Q. 5. What is the percentage of loss per H. P. of air and electricity under same conditions?

Q. 6. What percentage of saving is effected by an ordinarily efficient reheater, and what method is most popular?

Q. 7. What changes would be necessary in an ordinary steam engine, say, a hoist or pump to do effective work with compressed air? I have run steam pumps with compressed air, but they did not seem to do exactly right. Was this due to the lower temperature of the air?

Q. 8. What is the most effective means of lubricating cylinders of compressed air machinery? Have seen cuts of direct connected compressors having Detroit lubricators on air as well as steam pipes. What takes the place, in the case of the air, of water of condensation in the steam apparatus, that is, what gives the extra pressure necessary to force the oil into the pipe?

On account of great cost of fuel, for gasoline as well as steam plants, the cost of building and keeping up roads and other considerations, it is proposed to work several of the mines of this district from a central power plant, thus practically all supplies would be landed at one point, power would be generated at a minimum cost for labor, and after getting the machinery necessary for each mine in place, any other material could be packed on muleback or transported by wire rope tramways. The machinery for the mines could be made in sections light enough to be packed on mules. For these reasons, I want to get the benefit of some other person's experience to help me out in sizing up the situation. There are several good prospects in this camp, but they are obliged to lay idle on account of the vast cost of power and transportation. Several outfits have been in here and blew in fortunes on reduction works before developing any of their mines and blocking out ore. The same amount of money expended on a power plant and development work would very likely have shown up something good. Any information or reference to good authority, or some plants in successful operation, will be appreciated by, yours truly,

Columbia, Ariz. W. M. DONNE.

P. S.—What is greatest distance at which air has been successfully used?

What would be the best pump for sinking in a shaft, using air?

The plan which has been suggested in this case of operating several machines from a central power plant, thus permitting all of the supplies being landed at one point and reducing to a minimum the operating and contingent expenses, has been adopted in many cases with great success, and generally speaking, this plan may be stated as a correct one. This centralization is especially desirable in your case, if we understand your letter correctly. The fact that you must transport your machinery in sections on mule back is unfortunate, but does not preclude the adoption of the central plant system. From this distance and without exact knowledge, it is impossible for us to specify just what equipment or what arrangement will produce the best results, and therefore our answer should not be taken as final in all respects. Answering your questions in order:

First: The first cost and cost of installation of an air compressor plant per horse power as compared with electricity, and what are the comparative weights per horse power? We take this to mean the air compressing machine with its steam engine and the electric generator with its steam engine. The table found in our July issue gives approximate data with regard to the weight per horse power of the compressor, weight per cubic feet of delivered air, and the approximate cost of cubic feet of free air produced. For your purpose it is safe to assume that the comparative weights of an electric equipment and an air equipment will be about the same.

Second: The cost of pipe and properly insulated wire, including in each case suitable supports, will depend in the case of air upon the volume to be transmitted, the distance and the final pressure desired. In a case of electricity, the cost will depend upon the final voltage necessary at the machines, the distances, and the amount of current for the machines to be operated. By varying these factors, the cost of the one may be increased and the other decreased, or vice versa. All things being equal, there may be a slight difference in favor of transmission by wire as far as the cost of the line is concerned, but you must bear in mind that electricity cannot be used for every purpose, and requires the highest skill to operate, whereas, compressed air will serve for everything but lighting and calls for only ordinary operating skill. The repair bill will be considerably less in the case of air machines than with electric apparatus.

Fourth: The advantages possessed by compressed air are in a general way as follows:

First, and foremost, compressed air drills are many times more satisfactory than any form of electric drill yet devised. They will do more work, require less attention, and are more durable and cost considerably less than electric drills. Their use is not accompanied by any danger, and a break in the air main cannot possibly cause any harm. The presence of air affords a continual assistance to ventilation, and it facilitates the work considerably by permitting rooms and entries being freed of smoke. The air machines are absolutely free of all danger to operators, are quickly and cheaply installed, and require no experience to make adjustment or repairs.

Hoists, engines and every variety of apparatus found about a mine can be operated by the air. In some instances water pumps have been connected with the air mains and held in reserve in case of fire, the air pipes becoming water mains and carrying water to the headings.

Fifth: The ultimate or final efficiency of a mining equipment operated by electricity throughout, of which there are very few, is no higher than an air plant. In the one case a boiler is used to furnish the steam to operate an engine in turn driving an air compressor. The air is transmitted through suitable mains and used in the mining apparatus. In the other case, the same boiler drives an engine in turn driving an electric generator and power is transmitted through wires and used in special apparatus. If pumps are driven by electricity, the current drives the motor which motor drives the pump. Air, on the other hand, operates the pump the same as steam. With drills the air operates directly on the piston, while with electricity it must operate the motor which operates the piston. You are safe in assuming that the final efficiency of either plant will not be alarmingly high, but all things considered, an air plant is likely to

be most satisfactory and cheaper to operate.

Sixth: An ordinary reheater operated as it would be under usual conditions, will effect a saving of from 20 to 40 per cent. averaging about 30 per cent. These devices are placed close to where the machines are to be operated, require very little attention, and are extremely durable. The most satisfactory method is to use the form which burns coke, coal, gas, or some fuel oil, and it has been found that a given quantity of fuel burned in a reheater will increase the volume of available air about six times what the same amount of coal would do if burned under a boiler to run a larger compressor. In operating hoists or ordinary steam engines using air, a jet of water sprayed into the exhaust pipe is sufficient to prevent annoyance from freezing, but this does not effect any economy. To run an ordinary steam engine hoist, or pump, with compressed air no changes are necessary other than a careful examination of all the parts to see if they are absolutely tight and working freely. It may be necessary to spray a jet of water into the exhaust, but this is used only to prevent freezing of the moisture which is nearly always present in compressed air. Your former trouble may have been due to low temperature of the air, but we cannot write any explanation of your trouble from the information you give. The most effective means of lubricating cylinders for compressed air is a form of sight feed lubricator arranged to allow the oil to feed in the cylinder. These have, as a rule, a bypass which allows the full pressure to press down on the surface of the oil and the oil feeds in by gravity alone. No trouble is experienced in lubricating compressed air machinery, it only being necessary in the case of a compressor to use a high grade oil which does not carbonize, stick, or volatilize at a low temperature.

EDITOR.

One of our subscribers and correspondents writes us as follows:

"We have a small upright engine at our shops which we have been running with steam. Lately we have put in a large Ingersoll-Sergeant Air Compressor, and are now running this engine by air. The exhaust pipe is 2 inches diameter and in a short time after starting up it became covered with an inch of ice its entire length, and finally froze up inside so that we had to disconnect the pipe. I would be very glad if you will give me your explanation of this in your monthly COMPRESSED AIR. M. M. G."

The so-called freezing of air in the exhaust pipe of engines and sometimes in other apparatus operated by compressed air is due entirely to two factors—the presence of moisture in the air and the reduction or lowering in temperature of the air as it expands in the engine cylinder and at the exhaust. The presence of moisture in air, all conditions being equal, depends upon the geographical location and the temperature of the air, the warmer the air the more moisture it will contain within certain limits. Further, on rainy days the air is frequently nearly saturated with water. If air of this character is compressed its volume is greatly reduced, while the moisture originally contained is then concentrated in the small volume. As this compressed air containing a large percentage of moisture passes through the receiver and pipe line a certain amount of its moisture is precipitated depending upon the fall or drop of temperature; the law being the colder the air the more moisture thrown down. If we allow the air to remain in the receiver or pipe line until its temperature is reduced to that of surrounding objects it still contains a considerable amount of moisture. Now if air in this condition is conveyed to any engine which depends upon the use of air expansively, the well known law of expansion of gases applies and there at once results a considerable fall in temperature as the air expands. The exact amount of fall is easily ascertainable according to the formula.

$$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{0.41} \qquad \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{0.29}$$

Let air at an absolute temperature T_1, absolute pressure p_1, and volume v_1, be compared to an absolute pressure p_2, and corresponding volume v_2, and absolute temperature T_2; or let compressed air of an initial pressure, volume and temperature p_2, v_2 and T_2, be expanded to p_1, v_1, and T_1, there being no transmission of heat from or into the air during the operation. Then the above equations express the relations between pressure, volume and temperature (see works on Thermodynamics) and Kent, 501; which is another way of saying that as the pres-

sure decreases in expanding the temperature of the air decreases in a certain ratio. This drop in temperature, even under ordinary conditions, is sufficient to cause freezing of any moisture which is contained in the air. Consequently, as the air issues from the exhaust nozzle heavily charged with moisture, snow or ice accumulates and may eventually clog the passage.

This principle of fall of temperature when a gas is expanded is made use of in all systems of gaseous refrigeration, whether using ammonia, carbonic acid or other gases. In fact, there is a method using compressed air itself for this purpose in very extensive service on ocean steamers known as the "Allen Dense Air Refrigerating Machine" which consists of an air compressor and an engine so connected that when the air is compressed it passes over into the engine and assists the steam in driving the compressor. As it expands and exhausts, the air is discharged through a system of coils of pipe which are submerged in brine tanks. Of course, in this system the air is dried before and after compression to avoid clogging of the passages.

Two methods are employed to prevent this so-called freezing of air, which it is seen is only freezing of the moisture in the air and not of the air itself. The first of these is to sufficiently dry the air before permitting it to pass into the conveying mains to which the operating machines are connected. This is done by inserting between the cylinders, in the case of compound compression, and after the compressor; in other cases a form of separator known as intercooler or aftercooler, as the case may be. This is a type of surface condenser in which circulating water is passed through tubes surrounded by the compressed air, the water flowing in one direction, while the air current is in the opposite. The spacing of the tubes is such that the air is split up into a series of thin layers. This rapidly lowers the temperature of the compressed air, and in so doing, precipitates the moisture in the form of drops which accumulate in the bottom of the receiver.

The second method is to employ reheaters which are nothing more or less than a special form of stove, fire being in the interior and the walls of the stove containing passages sufficiently large to permit the required volume of air to flow through without resistance and so formed as to permit the transference of the greatest possible amount of heat of combustion to the air. These reheaters are solidly constructed and extremely simple. They usually burn coal or coke, but are also constructed for oil or other fuel. They may be obtained in different sizes to suit the volume of air to be handled, and we refer you to our advertising pages for several concerns who make them. If a suitable size is selected and conditions are properly adjusted, a final temperature of from 250 degrees to 350 degrees may be obtained, which means an increase in the volume of air obtained of from 25 to 35 per cent.

In use these reheaters should be placed fairly near to the apparatus to be operated. It has been found that a definite amount of fuel employed in this way will give as great an increase in volume as from 6 to 8 times the same amount burned under a boiler in the usual way to furnish steam for a larger compressor.

Freezing at the exhaust is also prevented by arranging a jet of water to spray into the exhaust pipe, but this method gives no increase in the efficiency, and will not work unless the jet water is sufficiently warm and furnished in quantity sufficient to overcome the refrigerating effect of the expanded air, and is not to be recommended. The furnace reheating method is daily becoming better appreciated, and we recommend it in your case.

COMPRESSED AIR has from time to time published articles bearing on this subject, and we refer you to these for further information. The most important articles will be found in the issues of

April, 1898, Vol. III, No. 2, Page 409,
June, 1898, Vol. III, No. 4, Page 429,
Sept., 1898, Vol. III, No. 7, Page 483,
Nov., 1898, Vol. III, No. 5, Page 521,

Jan., 1899, Vol. III, No. 11, Page 554,
Feb., 1899, Vol. III, No. 12, Page 578,
Nov., 1899, Vol. IV, No. 9, Page 781,
Dec., 1899, Vol. IV, No. 10, Page 798.

Jan., 1900, Vol. IV, No. 11, Page 823,
July, 1900, Vol. V, No. 5, Page 978,
Nov., 1900, Vol. V, No. 9, Page 1091.

EDITOR.

U. S. PATENTS GRANTED JUNE 1901.

Specially prepared for COMPRESSED AIR.

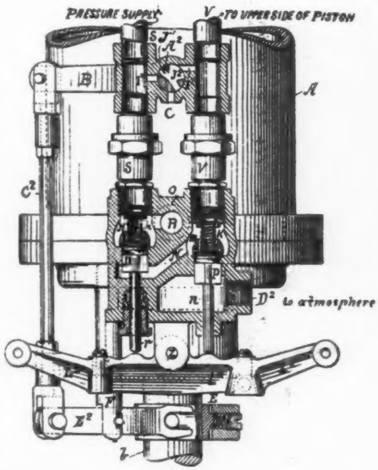
675,468. ACTION FOR PNEUMATIC MUSICAL INSTRUMENTS. Charles L. Davis, Chicago, Ill., assignor of one-half to August Heuer, Jr., same place. Filed Aug. 15, 1900. Serial No. 26,992.

675,490. ROCK-DRILL. Charles T. Litchfield, Spokane, Wash. Filed Oct. 8, 1900. Serial No. 32,403.

675,497. MOTOR. Calvin J. Polock, Kirksville, Mo. Filed Jan. 2, 1901. Serial No. 41,757.

675,528. VALVE DEVICE FOR PNEUMATIC HOISTS. Robert A. Rutherford, Philadelphia, Pa., assignor to the Pedrick & Ayer Company, same place. Filed Oct. 11, 1900. Serial No. 32,685.

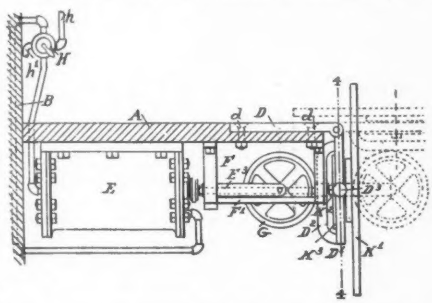
In a pneumatic hoist comprising a cylinder, piston and piston-rod and valve device whereby in operation the motive fluid may be admitted to establish an equilibrium of pressure upon both sides of the piston, an auxiliary valve device adapted to communicate with the supply-pipes leading to the respective sides of the piston and to the atmosphere, and means for automatically operating said valve device, so that the pressure is adjusted to check a movement of the piston from its suspended position in either an upward or downward direction.



675,581. VALVE-GEAR FOR GAS-ENGINES. George Alderson, Lasalle, Ill., assignor to Charles Brunner, Peru, Ill. Filed Jan. 25, 1901. Serial No. 44,748.

675,652. PNEUMATIC LIFT FOR WORK-BENCHES. Charles H. Doebler and Winfield S. Cooper, Springfield, Ill. Filed Sept. 4, 1900. Serial No. 28,893.

An apparatus of the class described, the combination of a bench, a table having a hinge connection with said bench, a stationary air-



cylinder, a piston slidable in said cylinder, means for supplying compressed air alternately on opposite sides of said piston, and a piston-rod connected with said piston and in operative relation to said table.

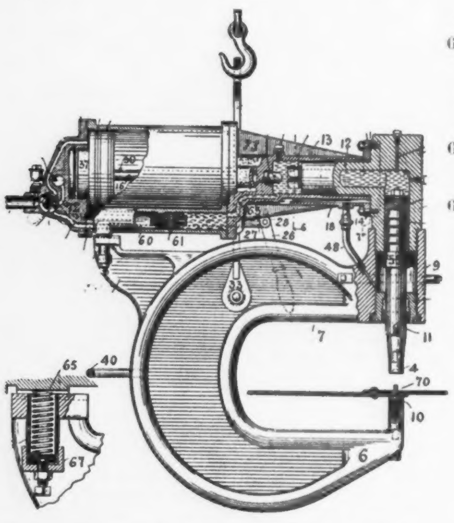
675,840. AIR-BRUSH. Columbus Phillips, Meridian, Miss., assignor of one-half to Jas. E. Minor, New Haven, Conn. Filed Oct. 10, 1900. Serial No. 32,568.

675,849. POWER-TRANSMITTER. Andrew Benson, Chicago, Ill., assignor of one-half to John P. Price and Robert P. Price, same place. Filed Jan. 31, 1901. Serial No. 45,410.

675,870. AIR-BRAKE. Charles A. Ball, Brooklyn, N. Y., assignor to the Standard Air Brake Company, New York, N. Y. Filed April 6, 1900. Serial No. 11,852.

675,880. PORTABLE PNEUMATIC RIVETER. John A. Carlisle, Philadelphia, Pa., assignor to the Pedrick & Ayer Company, same place. Filed Aug. 9, 1900. Serial No. 26,323.

A riveting machine composed of a yoke-frame provided with an anvil-die upon one arm; a cylinder and plunger fitted with a riveting-die upon the other arm; a liquid-chamber above said plunger communicating with a minor cylinder and piston for moving the riveting-plunger in contact with the work with a minimum volume of the motive fluid; a



larger power-cylinder and piston for compressing the rivet under a maximum or intensified pressure; a series of auxiliary cylinders and pistons for returning the power-pistons and riveting-plunger after compression, and a valve for controlling the motive fluid to and from the respective cylinders through suitable ports, and means for checking the speed of the returning piston at the termination of its stroke, the whole constituting a portable self-contained structure.

675,903. PNEUMATIC DOOR-CHECK. Seymour W. Peregrine, Portland, Me. Filed July 18, 1900. Serial No. 24,067.

675,981. GAS AND AIR HEATER FOR BURNERS. Constantin M. Seifert, New York, N. Y. Filed Jan. 10, 1901. Serial No. 42,758.

675,990. STOP-VALVE FOR PNEUMATIC TIRES OR THE LIKE. Luigi Way, Turin, Italy. Filed July 6, 1900. Serial No. 22,677.

676,016. SEPARATOR FOR HYDRAULIC AIR-COMPRESSORS. William O. Webber, Boston, Mass., assignor to Walter C. Carr, New York, N. Y. Filed Aug. 29, 1900. Serial No. 28,484.

676,019. AIR-BRAKE. Andrew J. Wisner, Philadelphia, and John S. Ely, Bridgewater, Pa., assignors, by direct and mesne assignments, of one-half to William F. Anderson, Philadelphia, Pa. Filed Oct. 4, 1899. Serial No. 732,481.

676,041. AIR-SEPARATOR. Charles H. Lane Cleveland, Ohio. Filed Feb. 23, 1900. Serial No. 6,178.

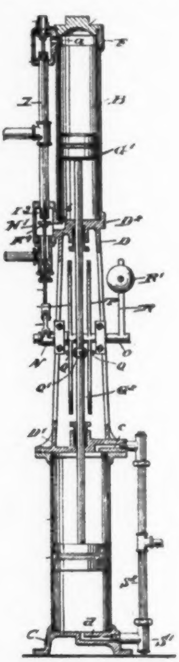
676,055. PNEUMATIC TOOL. Joseph J. Tynan, Philadelphia, Pa., assignor, by mesne assignments, to the Pneumatic Tool Improvement Company, same place and Camden, N. J. Filed Sept. 22, 1900. Serial No. 30,813.

676,080. APPARATUS FOR COMPRESSING OR EXHAUSTING ELASTIC FLUIDS. William Reavell, Ipswich, England, assignor to Reavell & Company, Limited, same place. Filed Nov. 17, 1899. Serial No. 737,361.

676,204. COMPRESSED-AIR SPRAYER. Frank Ripley, Grafton, Ill. Filed Sept. 4, 1900. Serial No. 28,889.

676,266. HYDRAULIC AIR-COMPRESSOR. Lee E. Mitchell, Boston, Mass. Filed Nov. 9, 1900. Serial No. 35,950.

The combination with a power-cylinder, a



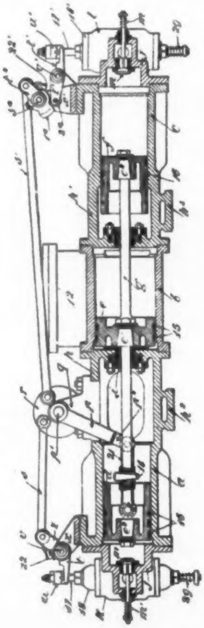
rod provided with a piston reciprocating in said cylinder, an air-compressing cylinder into which the piston-rod extends and an air-compressing piston carried by said piston-rod, of valve-chests opening into the power-cylinder at the ends thereof, a supply connection between the valve-chests, a reciprocating piston-valve in said connection and arranged to alternately open and close the connection to the valve-chests, and to alternately close and open the discharge for the waste-outlets from the valve-chests, and means for actuating said piston-valve from the piston-rod of the power cylinder, the said means comprising a shaft having a lug thereon means carried by said shaft and engaged by a cross-head on the piston-rod to impart a rocking motion to the said shaft, a crank-arm loose on the shaft and having spaced shoulders adapted to be alternately engaged by the said lug and a connection between the crank-arm and the valve-stem of the piston-valve.

676,279. SPRING AIR-GUN. Albert Shoenhut, Philadelphia, Pa. Filed Nov. 10, 1900. Serial No. 36,113.

676,291. PNEUMATIC SHEET-FEEDING APPARATUS. Anton Weiss, Franz Hell, and Kristof Oberding, Budapest, Austria-Hungary. Filed April 3, 1900. Serial No. 11,327.

676,349. COMBINED AIR-COMPRESSOR AND EXPLOSIVE-MOTOR. Francis H. Biasse, Paris, France. Filed Aug. 30, 1898. Serial No. 689,839.

A combined air-compressor and explosive-



motor comprising two single-acting explosive-cylinders *a* and *c* having inlet and exhaust ports with valves controlling the same; a double-acting compressor-cylinder *b*, placed between the said motive cylinders; one and the same piston-rod *g* on which the pistons *d* and *f* of the motive cylinders and the piston *e* of the compressor-cylinder are mounted; the rod *p* connected to the said piston-rod; the rock-shaft *p'* actuated by the rod *p*; the crank-disks *r* mounted on the said shaft; two pairs of pitmen *s*, *s'*, pivoted each to one of the said disks, and mechanism actuated by the pitmen for controlling the operation of the valves.

676,395. PNEUMATIC TIRE. Mark A. Heath, Providence, R. I., assignor to Mark A. Heath, Jr., and Charles Heath, same place. Filed Oct. 4, 1900. Serial No. 31,966.

676,398. AIR-BRAKE MECHANISM. John F. Mallinckrodt and William H. Sauvage, Denver, Colo.; said Mallinckrodt assignor of his right and said Sauvage assignor of part of his right to Charles C. Welch, same place, and the Sauvage Duplex Air Brake Company. Filed Sept. 21, 1900. Serial No. 30,666.

676,400. VALVE FOR PNEUMATIC TIRES &c. John A. Spencer, Los Angeles, Cal. Filed July 18, 1900. Serial No. 24,118.

676,401. AIR-COMPRESSION APPARATUS. Knut O. B. Textorius, Boston, Mass., assignor of nine-twentieths to John J. Howard, same place. Filed Jan. 5, 1900. Serial No. 500.

676,483. PNEUMATIC STRAW-STACKER. Edgar A. Wright, Canton, Ohio, assignor to the Aultman Company, same place. Filed July 10, 1899. Serial No. 723,389.

676,850. AIR-BRAKE MECHANISM. William H. Sauvage, Denver, Colo., assignor, by direct and mesne assignments, to the Sauvage Duplex Air Brake Company, same place. Filed June 5, 1900. Serial No. 19,186.

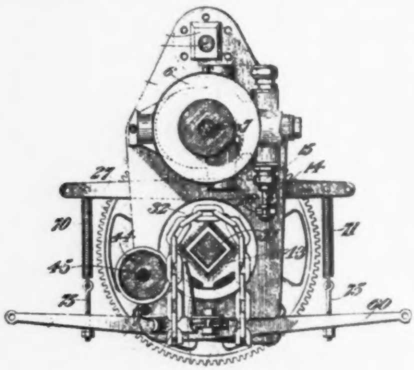
676,851. AIR-BRAKE MECHANISM. William H. Sauvage, Denver Colo., assignor to the Sauvage Duplex Air Brake Company, same place. Filed Sept. 28, 1900. Serial No. 31,361.

676,852. AIR-BRAKE MECHANISM. William H. Sauvage, Denver, Colo., assignor to the Sauvage Duplex Air Brake Company, same place. Filed Sept. 28, 1900. Serial No. 31,362.

676,871. PNEUMATIC RAILWAY-BRAKE APPARATUS. August Bruggemann, Breslau, Germany, assignor to the Deutsche Waffen und Munitionsfabriken, Carlsruhe, Baden, Germany. Filed Aug. 2, 1900. Serial No. 25,669.

676,931. HOIST. William F. Barrett, Orangeburg, N. Y., assignor to the Empire Engine and Motor Company, same place. Filed May 26, 1899. Serial No. 718,405.

A hoist, the combination with a frame, motor, motor-shaft, pulley, pulley-shaft, and means connecting the two shafts, of a drum upon the motor-shaft, a brake-strap supported in operative relations thereto, a motor-controlling lever upon the frame, a pair of co-operating levers, either being adapted to operate the brake-strap, one lever being connected with one end of the controlling-lever, and the other with the other end thereof, and means for operating the three levers.



676,993. CAISSON. William H. McFadden, Pittsburg, Pa., assignor to Consolidated Mining and Dredging Company, same place. Filed Oct. 26, 1900. Serial No. 34,479.

677,122. ROTATING-PISTON PUMP OR COMPRESSOR. Josiah Dow, Philadelphia, Pa. Filed July 7, 1900. Serial No. 22,784.

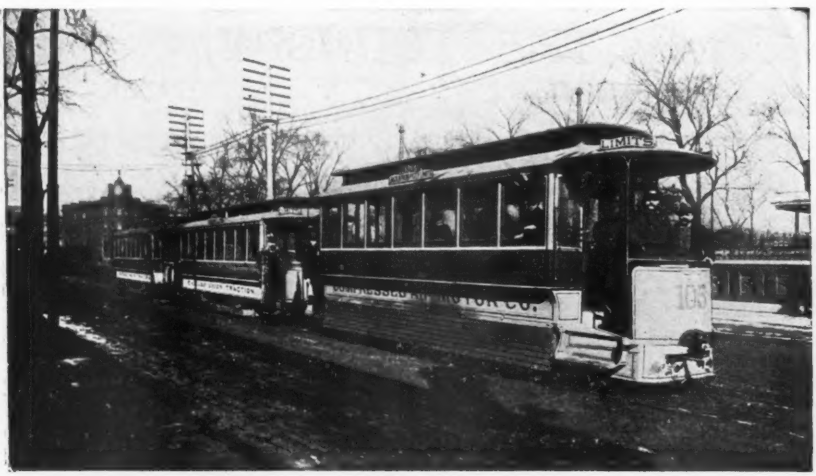
677,290. PNEUMATIC TIRE. Pardon W. Tillinghast, Edgewood, R. I. Filed Aug. 2, 1900. Serial No. 25,714.

COMPRESSED AIR COMPANY.

Controlling the American Air Power Company of New York
and the Compressed Air Motor Company of Illinois.

COMPRESSED AIR MOTORS

FOR STREET, SUBURBAN AND ELEVATED RAILWAYS.



The above cut is of a 28 foot Compressed Air Motor Car hauling two trail cars in Chicago.

COMPRESSED AIR CO.,

621 Broadway, - - NEW YORK.
1032 Monadnock Block, - CHICAGO, ILL.